LANE MEDICAL LIBRARY STANFORD
I611 .K41 1927 OLD
The fundamentals of school health / by J
24503195079

C 40

SAN FRANCISCO TUBERCULOSIS ASSN.
20 SECOND STREET

LANE
MEDICAL LIBRARY

Girt
San Francisco Tuberculosis
Association

USIS ASSN.

THE FUNDAMENTALS OF SCHOOL HEALTH

"TEACHER."

THE FUNDAMENTALS
OF
SCHOOL HEALTH

BY

JAMES KERR, M.A., M.D., D.P.H.

CONSULTING MEDICAL OFFICER, LONDON COUNTY COUNCIL
MEMBER INTERNATIONAL COMMISSION ON STANDARDS OF ILLUMINATION
OFFICIER DE L'ENSEIGNEMENT PUBLIQUE

Formerly

HONORARY SURGEON BRADFORD ROYAL EYE AND EAR HOSPITAL
HOWARD MEDALLIST, ROYAL STATISTICAL SOCIETY
INGLEBY LECTURER, UNIVERSITY OF BIRMINGHAM
SCHOOL MEDICAL OFFICER FOR LONDON, ETC.

SAN FRANCISCO TUBERCULOSIS ASSN.
20 SECOND STREET

NEW YORK
THE MACMILLAN COMPANY
1927

LIBRARY

(*All rights reserved*)

Printed in Great Britain by
Unwin Brothers, Ltd., Woking

LANE LIBRARY

I611
K41
1927

PREFACE

THE hygiene of the growing age as a scientific study is more important nationally than that of any other period.

This book presents the basic facts on which such study is founded. They have been collected from my own experience, and by help of an incomparable staff of enthusiastic workers with whom it was my good fortune to be associated, and who in the earlier years of the century finally established the value of school hygiene as a necessary public service.

In addition, several colleagues have to be thanked for help and advice with materials and reading of proofs. Correspondents and workers all over the world have aided in what otherwise would have been an almost impossible task.

The history of school hygiene in this country, its present dissociation from education, the necessity for reforming, pruning, and thinning the clerical burden of the scholar, and for stopping gaps in relation to problems of life and health ; the politics of the developmental ages, and efficient methods of securing healthy schools, and its merited chance to every child, are adumbrated and implicit in this book. Discussion of these topics being foreign to its scientific aim is left for a future work.

From the country where the Anglo-Saxon child develops at his best, comes the frontispiece of the infant class at Blackfriars School, Sydney.

JAMES KERR.

95712

CONTENTS

PAGE

PREFACE v

CHAPTER I

HEREDITY 1

Pedigrees—Mendelism—Chromosomes—Kallikaks.

CHAPTER II

GROWTH 13

Measurements—Chest—Cranium—Infants—Stature and Weight Tables—Environment—Relation to intelligence—Seasonal variations and standards.

CHAPTER III

PHYSIQUE 53

Upright position—Indices of Physique—Respiration—Exercise—Physical types—Inefficiency.

CHAPTER IV

PLAY 92

Children's play—Play centres.

CHAPTER V

NUTRITION 95

Basal metabolism—Food requirements—Vitamin—Index of nutrition—School feeding—War feeding—Nutrition classes.

CHAPTER VI

DENTAL HYGIENE 133

Eruption of teeth—Caries—Hygiene.

CHAPTER VII

RICKETS 143

Prevalence—Causes—Treatment.

CHAPTER VIII

LIGHT AS A HEALER 146

Ultra-violet rays—Window glass—Effects.

CHAPTER IX

PAGE

SLEEP 149

Necessity—Amount—Deprivation—Enuresis.

CHAPTER X

THE SPINE 154

Postural reflexes—Attitudes—Albuminuria—Examination—Curvature—Exercises.

CHAPTER XI

THE FOOT 170

Structure—Gait—Flat-foot—Pedographs—Hygiene.

CHAPTER XII

CRIPPLES 180

Historical—Prevalence—Prevention—Classes—Treatment.

CHAPTER XIII

SEATS AND DESKS 186

Existing—Dimensions required—Types—Single seats.

CHAPTER XIV

THE OPEN-AIR SCHOOL 202

Origins—Purpose—Provisions—Records—Playground classes—Feeding necessary—School journeys.

CHAPTER XV

TONSILS AND ADENOIDS 226

Anatomy—Sneezing classes—Aprosexia—Operations—Legal bearings—Results—Public health aspects.

CHAPTER XVI

TUBERCULOSIS 243

Prevalence—Varieties—Families—Infection—Diagnosis—Death-rates at school ages—Public health aspects.

CHAPTER XVII

RHEUMATISM AND HEART 266

Blood—Anæmia—Rheumatic syndrome—Chorea—Rheumatism in children—Treatment—Heart affections—Adolescent heart—Cardiac efficiency—Clinics.

CHAPTER XVIII

PAGE
MENTAL DEVELOPMENT 296

Consciousness—Neurons—Hughlings Jackson's levels—Order of development—Cerebral cortex—Periods of development—Conditional reflexes—Intellectual actions—Suggestion and imitation—Natural education—Habits—Personality.

CHAPTER XIX

INTELLIGENCE 331

Tests—Binet-Simon Scale—Additional—Porteus—Form board—Mental age—Scattering—Distribution of intelligence—Percentiles—Psychopathic children—Varieties of conduct—Superior child.

CHAPTER XX

SEX EDUCATION 377

Intellectual disturbances—Ignorance—Women—Information.

CHAPTER XXI

SUBNORMAL INTELLIGENCE 380

Definitions—Legislation—Examinations—Special schools—Classification — Microcephaly — Epileptic's care — Epiloa — Hysteria — Child suicide—Dementia præcox—Encephalitis—Moral imbeciles—Truants and wanderers—Delinquents—Sterilization—The Kallikak family—After-care.

CHAPTER XXII

THE PRE-SCHOOL CHILD 436

The Toddler—Neglect—Nursery schools—Nutrition—Sleep and exercise—Mental growth—Junglegym.

CHAPTER XXIII

VISION 447

Eye structures—External diseases—Seeing—Accommodation—Adaptation — Visual acuity — Infants — Bad vision — Colour — Refraction — —Squint — Astigmatism — Hypermetropia — Amblyopia — Myopia —Spectacles—Rejections.

CHAPTER XXIV

SUBNORMAL VISION 528

Easy treatment—Oral teaching—Myope classes—Lighting—Guides.

CHAPTER XXV

THE BLIND 535

Classification—Numbers—Physique—Braille—Welfare.

CHAPTER XXVI

PAGE

READING 544

Eye movements—Span of vision—Print—Legibility—Books.

CHAPTER XXVII

WRITING AND DRAWING 559

Writing—Alphabet—Eye-strain—Attitudes—Unusual writing.

CHAPTER XXVIII

HEARING 575

Ear—Hearing standards—Education by ear—Discharging ears—Ionization.

CHAPTER XXIX

THE DEAF CHILD 585

Causes—Classification—Education—Oral teaching.

CHAPTER XXX

SPEECH. 596

Evolution—Defects—Idioglossia—Physiological alphabet—Consonants.

CHAPTER XXXI

STAMMERING 605

Prevalence—Etiology—Educational care.

CHAPTER XXXII

CONGENITAL APHASIA 611

Speech centres—Word-blindness—Word-deafness—Agraphia.

CHAPTER XXXIII

DEXTRALITY AND LEFT-HANDEDNESS 624

Dextrality—Ambidexters—Mirror writing—Educational treatment.

CHAPTER XXXIV

MEDICAL INSPECTION AND TREATMENT 632

Purposes—Schedule—Health conditions—Out of school work—Minor ailments—Treatment centres.

CHAPTER XXXV

PAGE
SCHOOL NURSING 640
Ringworm—Sanitary care in schools—Nurses' room—Training.

CHAPTER XXXVI

HEALTH OF TEACHERS 648
Mortality—Illness—Suitable candidates—Tuberculosis—Neurasthenia.

CHAPTER XXXVII

INFECTIOUS DISEASES 659
General—Rate of Infection—Quarantine—Age prevalence—Whooping cough—Measles—Diphtheria—Scarlatina—Smallpox—Other diseases—School attendance—School closure.

CHAPTER XXXVIII

CLEANLINESS 723
Provision—Baths—Vermin—Scabies—Ringworm—Skin infections.

CHAPTER XXXIX

SITES AND BUILDINGS 741
Playgrounds—School plans—Stairs—Cloak-rooms—Water—General sanitation—Class-room space—Regulations.

CHAPTER XL

VENTILATION 764
Carbon dioxide—Things that do not matter—Physiological functions of air—Heat removal—Dryness—Katathermometer—School ventilation—Fans—Re-circulated air—Chilling.

CHAPTER XLI

WARMING 789
Heat carriage—Heating surfaces—Cold rooms—Regulations.

CHAPTER XLII

ILLUMINATION 795
Necessity — Brightness — Photometry — Windows — Skylights—Sunshine—Regulations—Artificial lighting.

CHAPTER XLIII

STATISTICS 824
Methods — Graphs — Tabulation — Classification — Control observations—Units—Personal equation—Frequency tables—Averages—Standard deviation—Probable error—Curve of error—Correlations.

INDEX 853

ILLUSTRATIONS

"Teacher" . . . . . *Frontispiece*

FIG.		PAGE
1.	Mendel's Law of Segregation	5
2.	Mendelian Heredity	6
3.	Colour Blindness and Sex Linkage	8
4.	First Generation of Kallikaks	11
5.	Chest Measurements	18
6.	Growth in First Year	21
7.	Glasgow Girls' Weights, Ages and Heights	25
8.	Crops of Children	30
9.	Girls' Ages, Heights and Standards	33
10.	Weight-Height Index and School Progress	34
11.	Rates of Development of Boys	35
12.	Stratz Scheme of Growth	42
13.	Chicago Percentiles Boys' Heights	46
14A.	Average Rates of Growth	48
14B.	Heights, Social Levels and Standard	49
15.	Respiratory Endurance Apparatus	61
16.	Venous Cisterns	62
17.	Harvard Postures	66
18.	Running Effects on Boys' Pulses	68
19.	World's Running Records	73
20.	Gymnastic Competitors by Age Grouping	*Facing page* 88
21.	Schiötz Competing Age Groups	*Facing page* 88
22.	Nomograph for Dubois's Formula	97
23.	Calories, Food Requirements	99
24.	Milk Vitamin and Growth	107
25.	Thickness of Abdominal Fold	115
26.	War Effects on Physique	126
27.	Molar Tooth Structure	134
28.	Eruption Temporary Dentition	135
29.	Eruption Permanent Dentition	135
30.	Solar and Other Spectra	147
31.	Relative Depth of Sleep	150
32.	Amounts of Sleep Desirable	151
33.	Fatigue after Sleeplessness	152
34.	Normal Spinal Curves	157
35.	Spinal Attitudes at School Work	160
36.	Seven Records of Girls' Backs	163

FIG.		PAGE
37.	Silhouette Graphique	165
38.	Position of Apex of Spinal Curves	166
39.	Arch of Ankle	171
40.	Oblique Joint of Ankle	172
41.	Tendons on Inner Side of Foot	173
42.	Pedographs	177
43.	Crippling in Pre-School Ages	182
44.	Fahrner's Desk	188
45.	Glasgow Barnard Street Desk	192
46.	Spellmann's Hanover Desk	194
47.	The Rettigbank	195
48.	London Dual Desks	195
49.	Bennett or Canadian Type Desk	196
50.	Sheffield Desks	196
51.	Minneapolis Seat Desk	199
52.	Elgin Adjustable Seat Desk	199
53.	Growth in London Open-air Schools	208
54.	Growth in New York Schools	209
55.	Seasonal Variation in Two Boys	214
56.	Comparative Growth in Tonsil Cases	240
57.	Mortality, Rheumatism, Chorea and Heart	280
58A.	The Vertical, Narrow or Tubular Heart	282
58B.	The Normal Heart	282
58C.	The Flat or Wide Heart	282
59.	A Sensory Neuron	299
60.	Spinal Reflex Arc of Knee Jerk	301
61.	Main Paths in Central Nervous System	303
62.	Section of Brain at Birth	306
63.	Section of Brain at 5½ Months	306
64.	Flechsig's Areas of Myelination	307
65.	Cranial Capacity of Various Social Classes	314
66.	Periods of Nervous Functional Development	316
67.	Binet's "Faces"	335
68.	"Missing Features" Test	338
69.	Binet's "Designs"	340
70.	Reversed Triangle and Folded Paper Tests	343
71.	Terman's Ball and Field Test	345
72.	Heilbronner's Test	346
73.	American "Code" Test	347
74.	Healy Form Board A	351
75.	Healy Form Board B	352
76.	Yerkes' Point Scale Results	356
77.	Chart of Hull Special Scholars' Abilities	357
78.	Normal Distribution of Mentality	358
79.	Percentile Mental Ages in London Scholars	359

FIG.		PAGE
80.	Diagram of Types of Nervous Functions	363
81.	Age Histories of American Women	378
82.	Mental and Calendar Ages Reformatory Boys	421
83.	Five Generations of the Kallikaks	429
84.	The Junglegym	*Facing page* 440
85.	Scheme of Developing Eye	447
86.	Section of Eye	448
87.	Fundus Oculi	450
88.	Relationships of Orbital Structures	451
89.	Section of Conjunctiva and Lids	453
90.	Introduction of School Doctors in Genoa	456
91.	Various Pupillary Conditions	462
92.	General Plan of Retinal Structure	463
93.	Retinal Adaptation and Changes	464
94.	Changes in Accommodation	467
95.	Range of Accommodation and Age	469
96.	Measurement of Visual Acuity	472
97.	Defective Visual Acuity, Age and Standard	475
98.	Very Bad Vision in Various Districts	481
99.	Percentage Normal Vision in London	482
100.	Accommodation and Distance of Work	489
101.	Refractive Conditions of Eye	490
102.	Various Types of Lenses	492
103.	Record of Retinoscopy	494
104.	Focussing by Normal and Astigmatic Lens	499
105.	Percentages of Myopia in Govan	506
106.	Cylindrical Spectacles and Bending	513
107.	Blind Spot and Area of Clear Vision	545
108.	Cut Types	546
109.	Type Body and Type Face	551
110.	Simplest Alphabetic Forms	561
111.	Sloped and Vertical Writing Compared	562
112.	Speed of Writing	567
112A.	Practised Writer	567
112B.	Unskilled and Young Child's Attitude in Writing	567
113.	Lettering Standard which Errs	569
114.	Unusual Writings (Agraphia)	572
115.	Hysterical Tremors Relieved	573
116.	Membrana Tympani	575
117.	Section through Ear	576
118.	Observational Field in Lip-Reading	591
119A.	Vowel Sounds	603
119B.	Stop Positions for Consonants	603
119C.	Stop Positions in Nasals	603
120.	Percentages of Stammerers in London	606

FIG.		PAGE
121.	Chief Speech Centres of Cortex	612
122.	Nerve Connections in Echolalic Child	617
123.	Dextrality in Population	627
124.	Nurse's Room in an American School	645
125.	Age Distribution Detroit Zymotics	670
126.	Edinburgh Measles Notifications	673
127.	London Zymotics for Forty Years	674
128.	Four Outbreaks of Measles in a Family	675
129.	Calendar of Measles Events.	678
130.	Measles Outbreak in a Hampstead School	683
131.	Measles Mortalities in London	684
132.	Arrangement of Diphtheria Cultures	689
133.	Seasonal Prevalence of Diphtheria	698
134.	Out of School Infection in Diphtheria	699
135.	Class Outbreak of Diphtheria	700
136.	Chains of Infection in Scarlatina	709
137.	London Weekly Zymotics Mortality for Ten Years	720
138.	Nit on Hair	729
139.	Central Hall School Plan	745
140.	Reid's Staffordshire Schools	747
141.	American School and Cloak-rooms	748
142.	London "Forty-eight" Room	754
143.	Erismann's Pattern Class-room	755
144.	French Class-room	756
145.	Comparative Class-room Areas	759
146.	English Class-room Areas	760
147.	Kata-thermometer	778
148.	Reflection of Light	798
149.	Average Illumination by Daylight	799
150.	Weber's Raumwinkelmesser	801
151.	Portable Lumeter	803
152.	Daylight in School Hall	804
153.	Illumination on Lower Floor Room	806
154.	Illumination on Higher Floor	808
155.	Effective Sky Area	809
156.	Artificial Lighting in Hall	821
157.	Measles Records of Two Classes	825
158.	Measles Outbreak in Village School	826
159.	Chart from Rachel McMillan School	827
160.	Comparison Graphically of Heights	828
161.	Heights of 1,347 London Children	837
162.	Standard Deviation Heights and Weights	843
163.	The Normal Curve of Error	846

FUNDAMENTALS OF SCHOOL HEALTH

CHAPTER I

HEREDITY

The natural history of the child is one of the most wonderful things in the world. Its growth and development can only be observed, they are beyond comprehension. Even noting of the changes occurring, and their extent, has only been accomplished incompletely.

Through any study of School Hygiene, as in almost every page of this work, gaps and lacunæ occur. Vague and general statements may gloss them over, but there is much which only careful observation and accurate reporting will remove.

Clearly defined statements are necessary if knowledge is to be advanced. "A class-room for younger children should be suitable, and have furnishings appropriate to the size and age of the children," may read well in a Report, but it is mere verbalism and conveys no useful information. It is the kind of statement to avoid in honest work. So here, whilst attempting to keep clear of empty expressions, only the merest outline can be given to indicate how factors act, as these hereditary factors often seem to be causes to consider in connection with many school problems.

The Inheritance of Life.—A child, in common with anything which lives, differs from material which is not alive. It has inherited from other living beings the quality of life. At every point it is always changing, and yet locally an average evenness is kept up; so that if health is to be maintained the blood, for instance, scarcely varies in composition although there are unceasing changes about a normal. To take the case of its alkalinity, the reaction lies within the limits of tap and distilled water—variation beyond this is scarcely compatible with life.

In this wise, various structures and secretions are constantly being adjusted and compensated; cerebro-spinal fluid has about the same minute percentage of salts; bile, gastric juice, structure of teeth, composition of the lens, every structure and function remains always changing but scarcely varying from its normal,

and yet this normal or average is the result of unceasing change and adjustment, within narrow limits which alter slowly but invariably, till at last a failure comes and somewhere a fine balance is upset, and the life of the individual ceases.

This incessant turmoil in the living body, however, is there as the result of activity of chains of others who have preceded it through æons, and run the cycle of their course to the inevitable end.

In each one is summed results of myriads, so that every child of American grandparents in New England has descent from Dutch or *Mayflower* Pilgrims, as every native of Old England has Tudor, Plantagenet, and Norman blood in their veins. Each one is descended from warriors, priests and kings, as well as useful workers and tillers of the soil.

Beginning as a cell, which when the writer first met an account of it in his school-days he pictured as about the size of the hundredth part of a pin-head, through fertilization by a still more minute cell, it grows and, in a few days, from cell division and multiplication at an enormous rate, there is a little living thing like a maggot in size and appearance. Then it broadly and roughly recapitulates in growth and functions the long descents of its ancestors, so that it soon has the essential structures of a lowly fish, then of an animal that crawls, till it grows to the appearance and attitude of one of the higher mammals, and ere in nine months it comes to birth it has become distinctly human. At the moment of conception, when the ovum becomes fertilized, it inherits all these qualities. All its potentialities, or want of potentialities, are then summed by heredity derived from its ancestry. What it becomes, and to what it attains, depends on the chance its environment gives for full development of those endowed possibilities. The first acquired is most fixed by ages of heredity, the latest least fixed and most plastic, and consequently the most susceptible to that environmental process which we speak of as education. Like body and soul, nature and nurture are essentials for the full man.

It is difficult to say in particular and with certainty which is greatest of the forces to give the particular impress to the future citizen—whether they are those of nature which he has inherited, or those of nurture impressed on him by peculiarities of environment. Even before birth both factors come into play, and it is not possible wholly to disentangle their effects. As Matthews Duncan used to say, "Cut fingers may be hereditary." It seems quite probable that liability to contract, say, scarlet fever may be inherited, whilst on the other hand tendency to congenital cataract, night blindness, colour blindness, some forms of deafness, mental defects, word blindness, moral obtuseness, left-handedness, or even broken bones appears in certain families.

Where some marked quality is to be noted a few instances may throw light on the whole process. In most human characteristics, any variation in a quality is seen in different cases to present a continuous change from the commonest amounts to the rarest degrees. The main value to be obtained for public purposes concerns large numbers. Under such circumstances statistical processes are the most useful methods for estimating the influence of heredity. This is done by calculating correlations between the particular qualities in parents and children.

The earliest attempt was Galton's Law of Ancestral Heredity, where he estimated that over considerable numbers of individuals the influence of father and mother respectively would be equal.

So far as resemblances are concerned, he assigned influence of the parents as a half of the total, influence of grandparents being a quarter, and of the nth ancestor as $(0{\cdot}5)^{2n}$.

Professor Karl Pearson, however, has shewn that the parental contribution is 0·6244, the grandparent is 0·1988, and the great-grandparent 0·063.

Charting of Pedigrees.—Where observations of absence or presence of certain qualities are being noted in a family, it is often useful to make out a pedigree in the form of a diagram, beginning with the farthest back relatives that can be traced.

Certain conventions are useful here; for instance, males are represented by a small square, females by a circle, individuals whose sex is not noted by a triangle; although formerly females were often represented by the sign ♀, Venus's looking-glass, and males by the spear and shield of Mars, ♂. An uninterrupted horizontal coupling line expresses marriage, whilst a dotted couple express other unions.

The family (sibship) of each couple is expressed by branches drawn down from the coupling line. Each generation can be referred to from the eldest as first, by Roman numerals. Each sibship in the generation by a letter of the alphabet, and individuals of the sibship by Arabic numerals; husbands or wives of members being indicated by an additional small Greek letter. To save space several members of the sibship may be marked by one sign with their number included. Where a member has died in infancy, a sign two-thirds usual size is used, and for a still-birth a sign one-third the size. Twins are bracketed. Where a particular defect is being followed out its occurrence is indicated by blacking in signs fully, and in many cases published capital letters are inscribed in signs to indicate defects or normals. Signs so used are: A for alcoholic; B, blind; C, criminal; Ca, cancer; D, deaf-mute; F, feeble-minded; I, insane; Id, idiotic; Imb, imbecile; N, normal; T, tubercular; S, syphilitic; and so on. An asterisk or a dot below and to the left of the sign indicates a special note of that case, and in any notes it would be referred to by the Roman number of the

generation, letter of the sibship, and Arabic number indicating the individual.

The correlation between parents and children found by statistical methods of the Galton Laboratory may be quoted (Table 1).

The Machinery of Heredity.—One of the thirteenth-century writers on the subject of human beginnings entitled his book *De Mirabile Mundi*, and how heredity works is still to-day a miracle beyond our comprehension, the first glimpses of its machinery just shewing.

Explanations given depend largely on the observations of Mendel. We can forestall Mendel's researches by the statement that Morgan and others (*The Physical Basis of Heredity*, 1919) have given a description of the mechanism. The little deeply staining threads of cell nuclei, which in process of cell division by karyokinesis

Table 1.

Character.	Correlation.	Authority.
Physical—		
Stature	0·51	Pearson and Lee
Span	0·46	Pearson and Lee
Forearm	0·50	Pearson and Lee
Eye colour	0·50	Pearson and Heron
Psychic—		
General intelligence	0·58	Pearson
Pathological—		
Deaf mutism	0·54	Schuster
Insanity	0·53	Heron
Mortal phthisis	0·50	Pearson
Rheumatism	0·46	Williams, Bell, and Pearson

divide, separate, and reunite to form two nuclei, are called chromosomes. The chromosomes of sex cells are only half the number of those of a somatic cell. The cells with reduced number of chromosomes are called gametes.

In fertilization gametes from each parent unite to form a new combination containing the whole number of chromosomes. This is the zygote. From its divisions come future sex cells, and somatic cells which form the body.

Germ plasm is the continuous stream of life, passing through gamete and zygote alternately. The soma is a side branch of temporary existence to protect the main stream of germ plasm.

These chromosomes are bearers of heredity. Inherited characters, which are entirely independent, never exceed the gametic number of chromosomes. Where more pairs of hereditary characters are present than chromosomes, some of them are found in some way linked.

Mendel worked out laws of heredity independently of this knowledge of the cells. It is a great aid in understanding his results. He first used peas with tall plants, and also peas with short plants, getting pure strains of these. Tall plants only producing tall plants, we can represent as having zygotes T T. Similarly short only producing short *t t*. Their respective gametes are T and *t* only. Crossing tall T T with short *t t*, individuals are got T *t*. They might be tall or short or neither, actually they were tall.

This was the first generation, F_1. When used for breeding they produced gametes T and *t*, but never T *t* or neither. T and *t* remained pure and unaltered by their previous association in the zygote T *t*. This gave Mendel his law of segregation of the determinants T or *t*, for tallness or shortness. If now two of these T *t* individuals were crossed, one-third, the tall, resemble the tall grandparents ; they are T T or homozygous. Two-thirds differ from the tall grandparent ; they are T *t*, or heterozygous. Tallness is said to be dominant. The short are all of the same kind as the short grandparent, *t t* ;

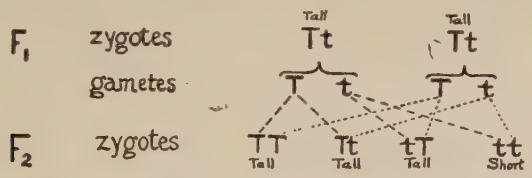


FIG. 1.—ILLUSTRATING MENDEL'S LAW OF SEGREGATION OF THE DETERMINANTS.

they are homozygous. The shortness is said to be recessive. The gametes arrange themselves according to the laws of chance : Mendel's independent assortment. In some cases, as the flowers of *Mirabilis jalapa*, pure strains have either white flowers or red flowers, but the heterozygous are pink. If two pink hybrid flowers are crossed there should be one white, two pink, and one red flower. The same has been shewn for some fowls, pure white or pure black or crossed blue. Two blues then crossed give a black, two blues, and a white.

The Mendelian principle is that in great measure the properties of organisms are due to the presence of the distinctly detachable elements separately transmitted. The chromosomes formed from the nuclei of the sexual elements in fertilization are the carriers. It has even been determined that these elements or genes are arranged in linear order in the chromosomes, and some only in the chromosome concerned with sex. Secondly, a parent cannot pass on an element, and consequently the corresponding property which it does not possess.

A population thus consists of three classes of individuals : those pure for the presence of the particular property, having received

two doses, they are capable of transmitting it to all descendants, one from each parent, of the element ; those pure for the absence of the element, having received none of it they are themselves incapable of transmitting it ; and those cross-bred (heterozygous), which have received from one parent one dose only, and are themselves capable of transmitting it to some, but not to others, of their descendants.

The organism produces germ cells representing in nearly equal numbers the positive and negative elements brought together in fertilization. From this it is at once evident what enormous possibilities of variety in the fertilized cells may occur. For one quality only, there would be three possibilities—firstly, pure presence (+ +) from both parents ; secondly, heterozygous, two classes of similar character (+ −) and (− +) present from one parent in one class,

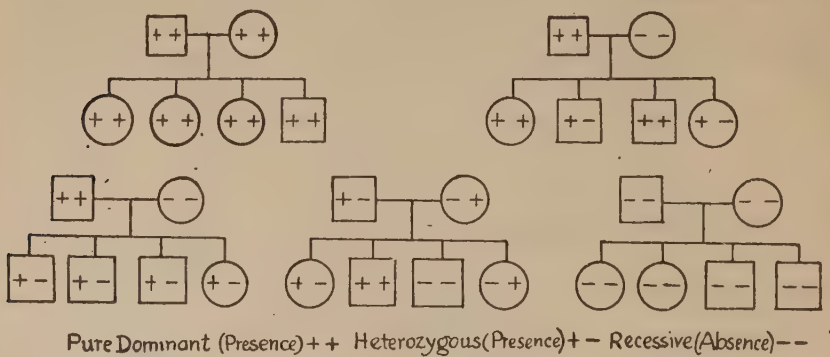


FIG. 2.—ILLUSTRATING THE VARIOUS FORMS OF MENDELIAN HEREDITY.

The sex of the offspring may be here neglected.

and from the other parent in the other case ; and thirdly, pure absence (− −) from both parents (Fig. 2).

For any additional qualities, all the possibilities will be rung in the way of permutation and combination ; so that for two qualities there would really be nine different kinds of individuals, although outwardly they would appear as three obvious varieties. If three qualities were considered, 64 individuals would have 27 apparently normal, although only one would really have all the positive qualities ; the rest being capable of transmitting one or more defects, and the remaining 37 would have seven different varieties of defectives.

When four qualities are considered, the variations would run into thousands. Obviously, the chances are infinite against there being two similar human beings, unless they came from the same ovum.

The first human characteristic recognized as Mendelian was

the peculiar malformation known as brachydactyly, another is congenital cataract. These conditions descend as *dominants*; they dominate the picture, and obviously unaffected members of the family do not transmit them.

Among other conditions recognized are: cartilaginous exostosis, hypoplasia of the teeth, coloboma iridis, some forms of night blindness, retinitis pigmentosa, distichiasis, hereditary tremor, Huntingdon's chorea, ptosis, and some forms of paralysis.

Recessive conditions usually appear from the union of parents apparently normal, though heterozygous for the condition; occurrence is rare and sporadic. Paralysis agitans may be one form, feeble-mindedness possibly another, albinism, epilepsy and rarer forms of disease apparently due to loss of some factor present in normal persons.

There are sex limited types: colour blindness, certain forms of night blindness with high myopia, hæmophilia, a form of nystagmus, too, are instances. Innumerable little tricks and traits exist which descend as hereditary characters for a generation or two. It is also possible, as experimental studies have shewn, that a character may be wanting not by absence of the determinants of the quality, but through some factor which inhibits its expression. Nettleship has shewn how night blindness, probably introduced by one individual, has persisted in a family through centuries. Hurst has demonstrated how the presence of pigment on the iris, giving brown or black eyes, is dominant, and its absence in grey or blue eyes is recessive.

The diagrams shewing the simplest facts of inheritance for a dominant characteristic do not, however, explain all the facts.

In truth, full explanation has not yet been reached, although rapid advances in knowledge are being obtained. For instance, colour blindness is transmitted through women, not themselves colour blind, heterozygous, but their colour blind sons do not transmit the defect to sons. Colour blindness in women is ten times less common than in men. Hæmophilia is a defect similarly transmitted. Colour blindness is said to be sex linked. Morgan determined that for certain insects the chromosomes in the dividing germinal cells had one different in the male to the female, this one being rounded and curved at one end. In a variety of the insect, where the colour of the eye differed, this difference went with the rounded chromosome.

In the human being, Von Winiwarter (1912) described 48 chromosomes in female, and only 47 in male cells. The female sex appears determined by this chromosome, absent in the male. In spermatogenesis there is an odd chromosome which has no fellow to pair with, and so half the spermatozoa contain an extra chromosome. They determine the female sex in ova which they fertilize, there being then

48 chromosomes. The other spermatozoa, with 47 chromosomes, determine the male sex. If, as may be possible, the factor of colour blindness is conveyed by the odd chromosome, the descent may be represented as in the figure.

The mating of a colour-blind man with a normal woman results in colour normal children, that being the dominant condition. An apparently normal daughter would contain, in half her ova, the factor of colour blindness derived from her father. The offspring with her mating with a normal man would contain some colour-blind males, and some females, like herself, with the colour-blind factor recessive.

Marking the female chromosomes XX, and XY for the male, and

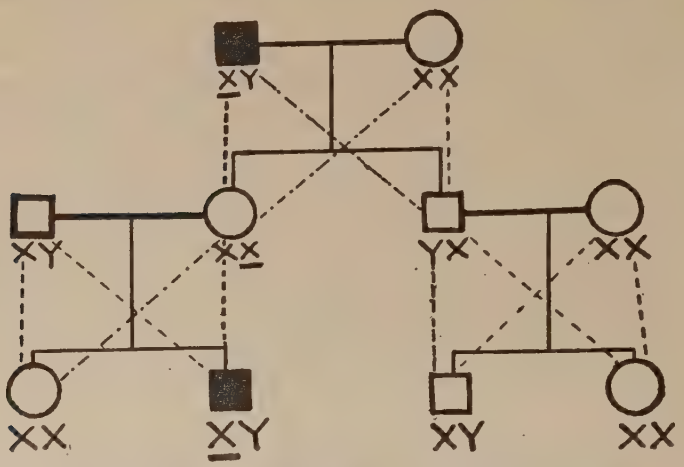


Fig. 3.—COLOUR BLINDNESS AND SEX LINKING.

underlining $\underline{X}$, the chromosome carrying the factor for colour blindness, we can follow the heredity in the figure.

Morgan's studies shewed that certain qualities (genes) were linked in the same chromosomes, and later work by E. Baur on antirrhinum has confirmed a topographical position of the transmitted qualities in the chromosomes.

The possible variations are endless when all the factors which contribute the character, physical or otherwise, are considered. The physiological variation in the individual contributed by circumstances of growth and environment, is a distribution which follows ordinary laws of chance by balancing about a mean.

There is also a physiological variation in the race which tends to a mean value, first stated by Galton as the law of regression. Tall fathers tend to have tall sons, but sons are nearer the racial average than their fathers. Short fathers, again, tend to have sons nearer the average—that is, taller than themselves.

In these matters, whatever education and environment may do, potentiality of ultimate results has been decided before birth, so that study and appreciation of the facts of heredity may become a matter of economic importance. It will be noted later how mental limits to the possibility of training exist, fixed ere the child is born. Potentialities of attainment thus fixed cannot be added to. They may be seriously diminished by conditions of environment, or neglect in procuring opportunities for development.

Certain poisons or toxins may affect germ cells and hinder full development. Instances of these are effects (first noted) of chronic lead poisoning, in which the development may be completely arrested. The effects of chronic alcoholism are also stated to act as racial poison. Syphilitic virus has an undoubted effect in hindering full development. There is a distinction between the congenital toxin of syphilis, which a child may have without infection by the organism and get rid of in a few weeks without future evil, and the spirochætal infection which will cause lasting congenital syphilis. Studies from Australia suggest a somewhat similar result from hookworm disease. The substances thus transmitted are just so much material, they do not grow and multiply, there is no law of transmission, and it is impossible to say that they will be further transmitted. They are substances capable of existing alone and apart, and form no essential part of the germ. Immunity to disease is probably largely of this nature, congenital, not hereditary.

Congenital conditions not due to heredity may affect growth, and common observation in elementary schools of populous areas points to later environmental conditions, like chronic fatigue and starvation, as playing a considerable part in delaying development in children.

The growth of tissues is aided and regulated by certain catalytic materials in the diet, the so-called vitamins, relative absence of which in the mother's food or in early infancy may be associated with imperfect growth and altered metabolism, as commonly seen in defective teeth, rachitic bones or cataractous lenses, or more rarely in aberrations of development as in many mentally defective or cretinous, and other forms of perverse growth.

At birth various injuries may occur, the most obvious in school-life being the result of cranial pressure and hæmorrhage which produces cerebral trauma with resulting paresis or even imbecility.

Infection of the conjunctiva from the mother's secretions may result in *ophthalmia neonatorum*, serious results being commonly due to gonococcus, whilst less serious cases occur from other germs as bacillus coli. These are scarcely congenital, and not hereditary.

The new-born child has on one hand a certain amount of resistance to disease, on the other special liability. In the case of common infectious diseases—measles, scarlatina or diphtheria—there appears

to be considerable immunity in the first months of life. Not, perhaps, entirely due to immunity acquired from the mother, as Brownlee notes that of nursing mothers admitted suffering from scarlatina, no babies under three months old contracted the disease. The loss of this immunity, he states, is almost instantaneous for scarlatina, between five and six months of age.

It has recently been shewn by the Schick test that immunity of a passive kind to diphtheria exists in about 80 per cent. of the new born ; this rapidly falls till between 20 and 30 months of age it has fallen as low as 28 per cent. with immunity, again steadily rising with an active immunity reaching about 80 per cent. at adolescence.

The first passive immunity is transmitted from the mother ; the second active has been acquired from minimal doses of the infection in the community, latent infection without disease ; and there may be a third actual immunity determined by hereditary make up, as shewn by the resistance of certain families to nervous or septic damage.

In comparison with these immunities also appears a want of resistance in tissues of young children, and this is the commonest form, as shewn by incidence of mortality rates, high at birth, sweeping rapidly down to a minimum about ten to thirteen years of age, then steadily mounting for the rest of life.

A study, for instance, of the course of *hypopyon keratitis*, as following on a slight injury, like scratching of the cornea, shews that the infant and the senile eye suffers severely and similarly, whilst the juvenile and young adult easily escape. Their liabilities in this respect are just reverse of what happens in diphtheria.

It is in the realm of socially defective that heredity becomes of overwhelming practical importance. The next move in the regulation of human affairs is not legislation to promote eugenics, but legislation to cut off the threads of defective human descent. This means segregation or sterilization of carriers of degeneracy. At present, economic laws are tending to destroy the threads of superior kind. Little is being done to remedy the evil. Writing in 1910 the author stated that, speaking generally, the requirements to be kept in regard to children under the Elementary Education Act (D and E), 1899, are not met. There is printed on the schedule a series of questions as to family history and as to the child's individual history. These queries are, as regards family history :

(1) What is the condition of the parents, mental and physical ?
(2) Are they temperate ?
(3) Has any near relative, dead or living, suffered from insanity, fits, gout, spitting of blood, consumption, scrofula, or any other hereditary disease ?

The first two questions are obviously intended to be answered in the roughest way, as affording a general bearing on the question of the child's education and care. The enquiries under (3) are definitely intended to bring out all facts readily accessible in relation to the hereditary disposition of the child.

These enquiries, at present, are a dead letter. They should embrace definite information as to the child's parents, aunts and uncles, and children of these persons. Without this information the Board of Education would be justified in stating that the records were insufficient. It should at least be done thoroughly for some of the cases, if only as mere demonstration.

The time allowed at present for medical examinations is wholly insufficient to record only defectives, and if we have a rate of four to a family, and it is a trifle greater in the families of defectives, the enquiry might embrace 28 individuals in the school generation, and 14 in the past. Including the grandparents, the record would

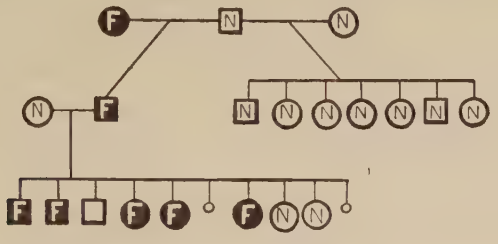


FIG. 4.—FIRST GENERATION OF KALLIKAKS.

run to 52 persons possibly, so that there must be a limit to the utility of enquiry.

An extensive enquiry was that made concerning a child at Vineland, and H. H. Goddard worked this up as the *Kallikak Family* (Macmillan, 1912).

This story, even allowing a large percentage for personal equation of the field workers, is instructive.

A family of good English blood of the middle class, settled in Colonial times, maintained an honourable tradition through four generations. During the Revolution a scion of this family, in an unguarded moment, with the help of a feeble-minded girl, started a line of mental defectives with an appalling history. After this mistake, he returned to the family tradition, married a woman of his own quality, a Quakeress, and carried on through her a line as respectable as that from which he came (Fig. 83).

There is the story of the Jukes family, published by Rich. L. Dugdale in 1877, and accounts of the population in some of the mountainous regions of the Eastern American states where hereditary degeneration of the race is evident.

It is doubtful whether, at first, evidence of value in the elucidation of individual cases would be obtained once in a dozen times. A careful and intensive social as well as statistical enquiry as to families of defectives and normals is desirable from the social point of view, and also for light shed not only on mental defect, but on crime, lunacy, incapacity for maintaining a decent standard of life, and so on. The results would be startling and certainly lead to legislation. Rapid progress is being made in regard to matters of heredity, and they are of great interest to every school worker, but space has only allowed the merest outline here.

CHAPTER II

GROWTH

Physical Development.—Development of the individual begins with division of the ovum, a cell perhaps the one hundred and fiftieth of an inch across, and proceeds by a rapid and slowing rate till the full stature of the adult has been accomplished, in a regular process by a definite time.

A multitude of influences affect the rate and extent of growth, and one part of school hygiene consists in tracing out and elimination or compensation of inimical factors.

The body is made of many organs, different in antiquity and heredity; some very variable, others almost unchanging. In both the nervous and muscular systems are strata of ancient and of recent formation. Blood-vessels, in their appearances and transformations during growth, recount a racial history of environments and habits which have left deep traces not otherwise to be suspected.

Comparative anatomy—or, if the term may be allowed, the archæology of the body—is not merely of fascinating interest, as shewn by Gaskell's study of the origin of the mammalian nervous system, Keith's study of man's attitudes, Wood Jones's analysis of the muscular system, and similar works, but is of the greatest importance to the school worker who is not to remain a mere indexing clerk of symptoms for treatment.

The order of development in organs and their functions proceeds from fundamental to accessory, from general to specialized. The fundamental and general are the first to come and the last to go. The heir of all the ages commences as a single cell growing and dividing into a mass of similar cells, ultimately some differentiate from others, till all the powers and potentialities of humanity are represented in these different cells and their special qualities and groupings. Nature, acting through heredity in a way which can be merely recorded but is not understood, has so habituated the cell division and growth that the earliest and first qualities and functions are the most fixed, and only the very latest and most specialized and human are capable of any material influence by the circumstances of environment.

These highest qualities, unless exercised in education, are not likely to be fully established. Nature is the great positive influ-

ence in life endowing with potentiality, and nurture has rather a negative influence in hindering, curbing, or stunting development of these powers, at its best merely allowing them expansion, but conferring nothing and adding nothing to Nature's gifts.

Fundamental powers of the cells make them utilize the materials of the environment to build up the body and extract energy from its surroundings to be expended in vitality. They develop naturally if opportunity is afforded, but they are also influenced by the master structures of the body, the muscles and nerve cells. These and, indeed, the mortal body itself, the soma, are but side branches in the stream of life. The soma is really a carrier, for a part of its existence, of the germ plasm which bears the stream of life through the centuries and conveys all the gifts of heredity to future ages.

Observation of the orderly development of organs and functions is gradually leading to a recognition of stages of evolution in the child's powers. Acts at first may seem meaningless, mere ill-regulated effects of nerve centres, like the babble of the baby, but gradually they become useful, done with deliberate effort and consciously purposeful, then with custom and habit becoming easily accomplished, they are at last relegated to almost unconscious automatic performances.

The course of natural education is by development of habit through the mere process of living, and should be imitated in formal education.

Premature appearance of nervous function means want of serial development of other functions. One of the stigmata of defect is irregularity in order of development. Premature education of parts of the nervous system out of natural order is possibly harmful to other parts, a kind of artificially produced defect.

The fundamental should come first, the accessory later. Infants who can read and write probably have been unwisely and badly educated. Full acquirement of powers and functions of organs presuppose also corresponding growth of the mechanisms and organs themselves. The big individual is a better machine for the purposes of life than a small one.

Fundamental functions or organs cannot be directly educated, Only indirectly are they affected. Long ages of heredity have fixed their requirements for development which a few generations of civilization or urbanization cannot alter.

Children must have certain conditions for nourishment and exercise if they are to attain proper growth. How far so many fail in this is one of the duties of the school doctor to demonstrate publicly so that remedies may be provided by the anxious politician.

Growth as a Measure of Development.—Normal vitality and development of a child can be judged by its growth. Causes which hinder or prevent attainment of the full standard are likely to

impair efficiency in other directions. This is one of the most ancient and trite observations on childhood. Attempts have been made to formulate mathematical equations for rates of development by Brownlee, Feldman and others. There cannot be said to be satisfactory standards, beyond average measurements. T. B. Robertson tries to demonstrate three growth cycles, varying in sex and with environment. He gives the very interesting case of English infants born in Australia weighing 8 to 10 ounces more than those born in England (*Amer. Journ. of Physiol.*, 1915–16).

Brownlee (*The Mortalities of Birth, Infancy and Childhood*, Sp. Med. Rep., No. 10, 1918) supposes an initial cycle of growth with some factor coming in after four years of age, and again with the impulse before puberty, but rejects Robertson's formula and assumes that two separate impulses to growth are decaying in geometric progression. On this basis he was able to formulate a continuous curve for growth of the child for the year of which its birth was centre point. There, however, is a considerable loss of weight in readjustment at birth, over-compensated in a few weeks, after that increase of weight is steady until four years of age.

For very young children weights are almost the only readily ascertainable measurements. Stem length, that is from the top of the head to the tuber ischii, can be measured by using an instrument based on the book slide ; the child being laid on its back and its legs held up at right angles, whilst the two ends are slid up to head and tuber ischii respectively, and the length between them read off on a scale.

Measurements of School Children.—Measurements of school children are worth taking accurately. Date, sex, age in years and months should always be recorded at the time. *Height* should be measured without shoes, the child standing as upright as possible, preferably with back to the wall or measuring board, and with head quite freely movable and eyes looking straight forward. A square measuring-rod of two metres' length graduated in millimetres is set up vertically, a triangular slider with its lower edge horizontal moves with it. *Sitting height* has obvious possibilities, but formerly was an inaccurate measurement varying with solidity of the thighs and buttocks.

This measure has now been made valuable as stem length by Dreyer. The individual is measured sitting with back to the wall and bearing weight on the tuber ischii, in a definite attitude, viz. " With the backs of the hands upon the platform, and with fingers pointing to the rear, the subject with knees bent lifts the lower portion of the body backwards until the sacrum is in contact with the front of the measuring standard ; the back is then straightened until the head comes into contact with the standard, and the eyes are directed straight forward."

TABLE 2.—HEIGHT AND CHEST MEASUREMENTS OF ENGLISH CHILDREN.

Age last Birthday	6–	7–	8–	9–	10–	11–	12–	13–	14–	15–	16–	17–
Edmonton Elementary School.						*Primary.*						
Boys—												
Height	107·7	113·0	117·9	121·7	127·3	131·5	134·7	142·1	145·1	—	—	—
Chest	54·9	56·6	57·8	59·7	61·3	63·0	65·0	67·6	64·5	—	—	—
Range	5·9	7·3	7·6	7·9	7·7	8·3	8·4	8·7	9·0	—	—	—
Girls—												
Height	107·4	112·1	117·4	121·4	126·9	131·7	137·2	145·0	146·7	—	—	—
Chest	54·0	55·4	57·5	58·6	60·6	62·3	65·1	69·8	68·6	—	—	—
Range	5·9	6·7	7·6	7·6	7·9	8·3	8·3	8·7	9·0	—	—	—
Manchester Grammar School.						*Secondary.*						
Boys—												
Height	—	—	—	—	134·5	139·7	144·0	149·5	155·1	161·0	166·0	168·8
Chest	—	—	—	—	62·7	64·5	65·9	68·7	71·5	75·1	78·5	80·9
North London Collegiate.												
Girls—												
Height	—	—	—	—	134·6	141·5	147·3	151·3	154·4	158·9	159·9	—
Chest	—	—	—	—	63·5	65·8	68·8	70·9	73·55	75·25	75·55	76·0

TABLE 3.—BALDWIN'S MEASURES. (AMERICAN CHILDREN.)

Birthdays ..	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Boys—											
Height ..	121	126	130·5	135·5	140	144·5	150·5	156·5	162	169	171·5
Chest ..	59·5	63	63·1	66	67	68·3	72	74·5	78	82	85
Girls—											
Height ..	118	124·5	129·5	135	140	146	152·5	157	159·5	162·5	162·5
Chest ..	63·5	66	68	70	72·5	75	78·5	81	83	85	85

Weight, for school purposes, should be taken in ordinary house clothes, without shoes. B. T. Baldwin, Schiötz and others are correct in stating that for scientific purposes nude weights should be taken. A steelyard graduated in tenths of a kilogram is the best weighing machine. The metric system is incomparably superior in freedom from liability to mistakes, although formerly pounds and inches were used in this country, and, unfortunately, still are in America. The spring weighing-machines at first used in schools have gone out of use on account of unreliability without frequent testing and constant attention.

Circumferential Measurements are made with a steel tape measure graduated in millimetres. Sometimes this is provided with a spring to give a fixed tension, a refinement scarcely required.

Details of instruments and technique of measurements other than those above can be found in the *British Association Report on Anthropometrical Measurements*, 1909; in *The Medical Inspection of School Children*, by Sir Leslie Mackenzie, 1904; and also in Baldwin's *Physical Growth of Children from Birth to Maturity* (University of Iowa Bulletin, 1921).

Circumference of the Chest.—Chest girth is not often taken in primary school inspections. In secondary schools and gymnasia, where estimates of physique have to be made, chest girth is to be noted.

The Instruction (1920) of the Anthropometric Standard Committee of the Medical Research Council directs the measurement to be taken at the nipple level in males, or just below the breast in females. The subject stands with arms hanging loosely by the sides, and should be encouraged to talk and breathe naturally. The measurement required is that of the normal, not expanded, chest, and is to be recorded in centimetres and half centimetres.

Baldwin, usually extremely accurate, is a trifle indefinite as to chest circumference, which he simply states as normal girth. Table 3 is compiled from his charts of averages on respective birthdays. They are greater than those of the previous table.

Dr. H. Gray, of Boston (*Journ. Am. Med. Ass.*, 1922), compares the so-called normal with mean circumference. He takes maximum and minimum and averages them. This, he states, is 1 per cent. more accurate in adults and 2 per cent. in children. If the mean is recorded in this way the range should also be given. Probably the best method and least open to criticism is simply to record maximum and minimum circumference. This was done for thirty-seven sample boys over their period of schooling (13–18) by R. E. Roper (*Journ. of Sci. Phys. Tr.*, Spring 1920, 42), and from his measurements the diagram has been prepared.

In the years 1909 and 1910 some 2939 boys in Dunfermline, of elementary school class, were measured, and the following returns are compiled from birthday values of the charts (Table 4).

Cranial Measurements.—Recent Australian work of Berry and Porteus suggest that cranial measurement will become of considerable diagnostic and educational value.

The maximum head length (L) is from the most prominent part of the glabella to the most distant point in the middle line on the

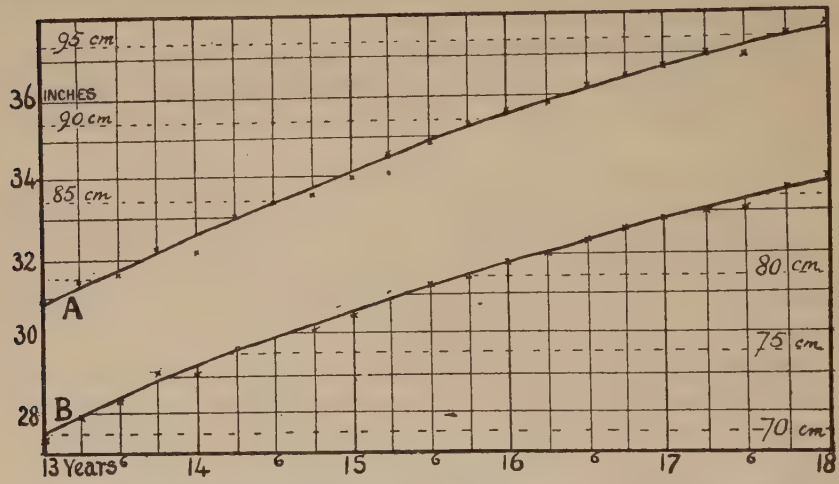


FIG. 5.—ROPER'S MEASUREMENT OF CHEST AT NIPPLE LINE IN BOYS.

A is maximum inspiration, B expiration.

TABLE 4.

DUNFERMLINE BOYS, 1909–10.

Birthdays ..	7.	8.	9.	10.	11.	12.	13.	14.
Hieght ..	116·1	121·5	126·9	131·4	135·6	140·6	145·4	151·9
Chest expansion	4·83	5·38	5·92	6·58	6·98	7·59	8·08	8·48

back of the head, the occipital point. The pressure of the callipers should be as great as can be comfortably borne.

The maximum head width (B), is, wherever it can be found, above the plane of the auditory meatus. It is to be taken between corresponding points in a transverse vertical plane.

The head height (H) is from the mid-points of the ear openings to highest point of cranium in a vertical plane when the eyes are directed to the horizon.

Cranial circumference has little school use, and Professor Berry

TABLE 5.

CAPACITY OF CRANIUM IN CUBIC CENTIMETRES.

	Pre-Pubescent.												Resting.	Pubescent.		Post-Pubescent.			
Age ..	0–	1–	2–	3–	4–	5–	6–	7–	8–	9–	10–	11–	12–	13–	14–	15–	16–	17–	18–
Boys ..	371	945	1075	1151	1186	1206	1225	1244	1264	1283	1301	1317	1326	1351	1358	1378	1402	1422	1447
Girls ..	333	849	966	1035	1066	1096	1121	1146	1162	1173	1199	1217	1226	1257	1271	1279	1304	1305	1307

TABLE 7.

STEPHENSON'S MEASURES FOR SECONDARY SCHOOLS.

Age ..	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Boys—														
Heights ..	104·9	111·45	116·48	120·42	126·21	131·47	135·81	139·82	144·93	151·38	158·16	164·23	168·14	169·69
Weights	18·36	20·31	22·39	24·67	27·12	30·11	32·24	34·83	37·96	42·38	47·57	54·42	58·58	61·20
W/H Index	175	182	192	204	215	228	237	250	261	280	300	331	348	366
Girls—														
Heights ..	104·26	109·19	114·25	119·60	124·58	130·02	135·28	141·65	147·31	152·05	155·06	156·64	158·03	158·0
Weights	17·97	19·43	21·35	23·63	25·52	28·19	31·05	35·08	39·83	44·24	47·81	50·95	52·24	52·80
W/H Index	172	178	187	198	204	217	229	247	270	291	308	324	330	334

suggests that it might with advantage be dropped from clinical use. These measurements are best made with good head callipers, or Hrdlicka's spreading compass.

TABLE 6.

HEIGHTS AND WEIGHTS OF ENGLISH AND AMERICAN CHILDREN, PRE-SCHOOL AGES.

Ages.	Heights in Cm.				Weights in Kilos.			
	Boys.		Girls.		Boys.		Girls.	
	Iowa.	Deptford.	Iowa.	Deptford.	Iowa.	Deptford.	Iowa.	Deptford.
2 –2¼	86·5	80·1	84·8	77·7	12·1	11·8	11·5	10·8
2¼–2½	88·2	81·9	86·4	80·5	12·5	12·1	12·0	11·6
2½–2¾	90·6	82·0	89·5	83·3	13·2	12·5	12·5	12·1
2¾–3	92·4	85·0	91·1	83·8	13·6	13·1	12·9	12·5
3–	94·2	87·5	93·1	87·0	14·0	13·3	13·5	13·6
3¼–	95·9	89·4	94·7	88·8	14·4	14·0	13·8	14·5
3½–	98·1	91·5	96·6	90·0	15·0	14·4	14·2	14·4
3¾–	99·6	93·0	98·2	91·8	15·4	14·8	14·6	15·0
4–	100·8	93·8	100·1	93·0	15·8	14·8	15·1	14·5
4¼–	102·2	94·7	101·2	93·2	16·1	15·1	15·4	15·7
4½–	104·0	96·5	102·9	96·8	16·4	15·7	15·8	16·5
4¾–	105·5	96·9	104·8	97·1	16·9	16·1	16·3	17·1
5–	106·9	98·3	105·6	98·4	17·3	16·2	16·7	17·7
5¼–	107·7	99·3	107·0	100·5	17·5	16·5	16·9	17·0
5½–	109·9	100·8	108·0	102·4	18·4	16·7	17·7	17·4
5¾–	111·9	103·8	110·3	102·5	18·7	17·7	18·1	17·7

Cranial capacity is found in cubic centimetres by use of Lee's formula.

For males—

$$\text{Cranial capacity} = 0{\cdot}000337\ (L - 11)\ (B - 11)\ (H - 11) \times 406{\cdot}01.$$

For females—

$$\text{Cranial capacity} = 0{\cdot}0004\ (L - 11)\ (B - 11)\ (H - 11) \times 206{\cdot}6.$$

Pelletier's method is somewhat similar.

$$\text{Cranial capacity in c.c.} = \frac{(L - 10)\ (B - 10)\ (H - 8)}{2020 \text{ (for males) or } 1940 \text{ (for females)}}$$

Berry and Porteus (*Intelligence and Social Valuation*, Vineland, 1920) have calculated brain volumes from recorded weights, and give averages from extensive numbers. They have also made out percentile tables for over five thousand Victorian children (*The Modern Psychology*, Report, R. J. A. Berry, 1921, Melbourne).

A considerable body of literature on growth in the first year of life is condensed in the accompanying diagram (Fig. 6).

The Nursery School Age.—At the age of 2 years many come into the nursery school. Variations to be expected are shewn by the table compiled from Baldwin's Iowa children, some 36,000 in all, and from several hundred poor class children in the Rachel McMillan Schools at Deptford (1921–2).

W. Stephenson (*Lancet*, 1888. ii. 560) collated a large number of secondary school measurements in England and America. His results were given in pounds and inches, but are here reduced to

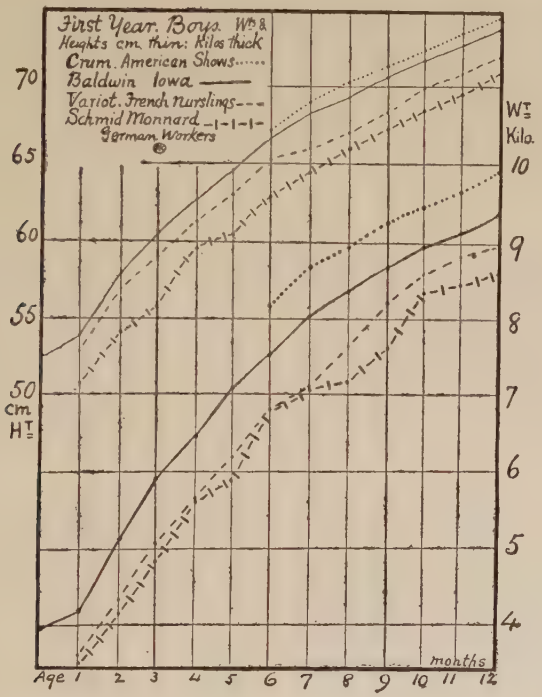


Fig. 6.—GROWTH IN THE FIRST YEAR.

the standards commonly used. They shew secondary scholars, age for age, much superior in physique to elementary.

Following these came a series of studies of American and Canadian children in Boston, St. Louis, Worcester, and Toronto by Bowditch, Porter, Boas, and others. Their work was well summed by Boas and Macdonald in the Reports of the American Commissioner of Education (Boas, 1897. ii. 1541 and 1904. i. 25, and Macdonald, 1898. i. 985). There is also a comprehensive paper by Burk on the growth of children in the *American Journ. of Psychology*, 1898. 253.

School Children's Measurements.—For children of school age, the first extensive English measurements were made by a Committee

of the British Association in 1883. The figures as general results do not represent the population, male professional classes being over-represented compared with artisans, and the reverse with females.

In 1905–6 some 20,000 London children were examined in Elementary Schools, and below are details worked out by Dr. F. Shrubsall (*L.C.C. Reports M.O.* (*Education*), 1906–7). There is a

TABLE 8.

HEIGHTS OF LONDON ELEMENTARY SCHOOL CHILDREN.

Last Birthday.	Series A (1906). Poor Class Urban.			Series B (1906). Good Class Suburban.			Series C (1905). Urban.		
	Cm.	±	σ.	Cm.	±	σ.	Cm.	±	σ.
Boys									
6	—	—	—	111·6	0·5	6·00	—	—	—
7	115·8	0·3	5·80	116·3	0·2	6·14	114·8	0·5	6·84
8	119·5	0·2	5·92	121·7	0·2	6·20	118·9	0·2	5·75
9	124·7	0·1	5·87	126·3	0·1	5·76	123·1	0·3	6·55
10	129·1	0·2	6·10	131·1	0·2	6·35	127·7	0·2	6·55
11	133·4	0·2	6·15	135·8	0·2	6·73	132·5	0·5	7·53
12	137·3	0·2	6·43	140·5	0·2	7·04	137·0	0·2	6·87
13	141·9	0·2	7·07	145·2	0·2	7·78	140·9	0·3	8·14
14	144·6	0·8	7·07	152·5	0·5	8·70	144·5	0·6	8·61
Girls									
6	—	—	—	111·4	0·4	4·63	—	—	—
7	115·7	0·3	5·95	115·3	0·2	5·44	116·0	0·6	5·46
8	119·2	0·2	5·91	121·2	0·2	6·26	120·5	0·3	6·12
9	123·5	0·2	6·07	125·8	0·2	6·25	124·5	0·3	5·90
10	128·8	0·2	5·95	130·9	0·2	6·58	129·5	0·3	6·92
11	133·5	0·2	7·07	136·1	0·2	7·50	134·3	0·3	6·56
12	139·3	0·2	7·80	141·9	0·2	7·97	140·3	0·3	8·21
13	144·8	0·3	7·96	147·8	0·2	8·12	146·2	0·3	8·33
14	148·6	0·7	6·84	153·8	0·4	7·13	151·1	0·7	7·25

further discussion, with tables, figures, and methods, of statistical details in the end chapter on Statistics.

Statutory Requirements for Great Britain.—Requirement for weighing and measuring children under the Education Code followed in accord with the provisions of the Act of 1907. The scheme was scarcely devised on scientific lines, and has not given material of value. It established, however, age last birthday and the convention of measuring without shoes. It asked for tabulated returns on the metric system, and unfortunately, also, in pounds and inches.

Various figures published from statutory examinations were collated by Tuxford and Glegg (*B.M.J.*, 1911. i). The main results

are averages derived from over half a million children. Sometimes spoken of as Standards, they can only lead to error if used as such.

Their work was considerably added to, and analysed, by Arthur Greenwood (*The Health and Physique of School Children*, 1913, P. S. King & Son) for children from 5 to 14 years of age. Height and weight of each group of children in different districts was expressed as an index number ; height or weight for the corresponding group in the elementary schools of the whole country being 100. An index for the whole district was then formed by adding indices

TABLE 9.

WEIGHTS OF LONDON ELEMENTARY SCHOLARS (1905–6).

Last Birthday	Series A.			Series B.			Series C.		
	Kilos.	±	σ.	Kilos.	±	σ.	Kilos.	±	σ.
Boys									
6	—	—	—	20·22	0·19	2·21	—	—	—
7	22·18	0·15	2·82	22·00	0·09	2·67	21·31	0·19	2·60
8	23·76	0·08	2·64	23·85	0·07	2·76	22·73	0·10	2·44
9	25·49	0·08	3·00	25·77	0·07	3·02	24·27	0·12	3·01
10	27·56	0·11	3·46	28·22	0·08	3·26	26·64	0·12	3·30
11	29·61	0·11	3·42	30·67	0·10	3·67	29·28	0·14	4·06
12	32·06	0·12	4·06	33·42	0·10	4·05	31·60	0·14	3·93
13	34·86	0·16	4·96	36·93	0·14	5·45	34·21	0·20	5·38
14	37·30	0·54	5·07	40·99	0·37	6·50	35·72	0·41	5·93
Girls									
6	—	—	—	19·74	0·16	1·97	—	—	—
7	21·30	0·13	2·60	21·09	0·09	2·37	21·03	0·32	2·81
8	22·52	0·08	2·65	23·18	0·08	2·90	22·89	0·19	3·08
9	24·55	0·08	2·86	25·36	0·08	3·29	24·50	0·13	3·02
10	26·83	0·09	3·12	27·59	0·09	3·41	27·10	0·17	4·01
11	29·44	0·13	4·23	30·59	0·11	4·15	29·35	0·16	3·94
12	33·10	0·17	5·24	33·98	0·15	5·55	32·84	0·23	5·50
13	36·81	0·20	5·96	38·56	0·18	6·63	37·33	0·26	6·24
14	40·16	0·70	6·57	42·48	0·33	6·36	40·91	0·56	5·71

of the various age groups and dividing by their number. Here, again, a depressed average being used as a standard, misleading impressions are likely, and it is doubtful whether the enormous labour was justified by the results obtained.

A great amount of work has been done on stature and physical measurements among American and Canadian children. Exhaustive papers on the subject are the classical papers on the growth of Toronto children by Boas (*U.S. Ed. Rep.*, 1897. ii. 1541) ; *The Experimental Study of Children*, A. Macdonald (*loc. cit.*, 1898. i. 985) ; Smedley's *Child Study in Chicago* (*l.c.*, 1902. i. 1095) ; *Statistics of Growth* (*l.c.*, 1904. i. 25) ; Baldwin's monograph on *Physical Growth*, published by the University of Iowa, 1921. For

TABLE 10.—ENGLAND. ELEMENTARY SCHOOL CHILDREN. (TUXFORD AND GLEGG.)

Age last Birthday	3–	4–	5–	6–	7–	8–	9–	10–	11–	12–	13–	14–
Boys—												
Height	92·4	98·2	103·0	108·0	114·7	119·3	124·7	129·4	134·2	139·8	142·5	147·1
Weight	14·86	16·29	17·54	19·33	21·20	22·86	25·12	27·42	29·93	33·05	35·15	38·15
Girls—												
Height	91·6	98·1	102·6	107·6	113·9	117·6	123·7	129·8	133·5	138·7	144·5	149·0
Weight	14·44	15·82	17·07	18·58	20·50	22·19	24·75	26·71	29·59	33·51	36·31	39·81
W/H Index—												
Boys	161	165	170	179	185	193	201	212	223	236	253	259
Girls	157	161	166	173	180	190	200	206	222	242	251	270

TABLE 12.—VALUES FROM WOOD AND BALDWIN.

Age	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Boys, Height in Centimetres—												
Short	114	119	124	129	135	137	142	147	152	157	162	165
Medium	122	127	132	137	142	147	152	160	165	170	173	175
Tall	129	135	140	145	150	155	163	170	178	183	183	185
Boys, Annual Weight Increase in Kilos—												
Short	1·81	2·27	2·27	2·27	1·81	3·63	4·08	4·99	6·35	5·90	3·17	1·36
Medium	2·27	2·72	2·72	2·72	3·17	4·08	4·99	6·80	4·99	3·63	1·81	1·36
Tall	3·17	3·17	3·17	3·17	3·63	5·44	7·26	4·99	4·08	3·17	1·36	1·81
Girls, Height in Centimetres—												
Short	114	119	124	127	132	137	145	150	152	155	155	155
Medium	119	127	132	137	142	147	152	157	160	163	163	163
Tall	127	135	140	145	150	157	163	168	168	170	170	170
Girls, Annual Weight Increase in Kilos—												
Short	1·81	1·81	2·27	2·72	2·72	4·53	5·90	4·53	3·17	0·91	0·45	—
Medium	2·27	2·72	3·17	3·63	4·53	5·90	4·53	2·72	1·81	1·36	0·45	—
Tall	3·63	3·63	4·08	4·99	5·90	4·08	3·63	1·81	1·81	0·45	0·45	—

practical use Wood and Baldwin have compiled tables, published by the American Child Health Association, which are reduced to metric measures in Table 11. R. Martin has examined Berlin and Munich figures (*Anthrop. Anzeiger*, 1924. 76) and the war effects in crops of children (1925. 59) in Munich Schools.

Of greater importance than weight or height at any given age is the annual increment of growth. In order to show the difference in growth of tall, medium, and short children, and to give yearly increments in weight, the middle 75 per cent. of all children within each age group for height are classified as of medium height; the 12·5 per cent. above this group as tall children; and the 12·5 per cent. below as short children, in Table 12.

These increments show that tall children have acceleration in

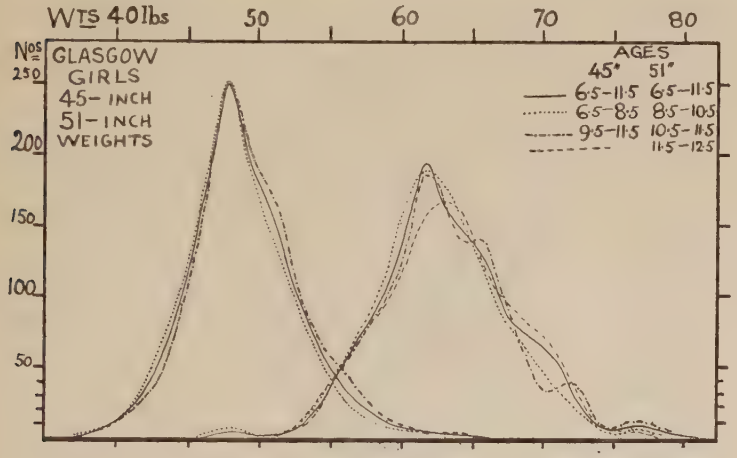


FIG. 7.—GLASGOW GIRLS' WEIGHTS IN VARIOUS AGE GROUPS, FOR 45- AND 51-IN. HEIGHTS.

growth at adolescence, both in height and weight, earlier than medium children, and that medium children have their acceleration earlier than short children.

For each year in earlier ages (5 to 10 years) both boys and girls shew a variation of two to three pounds in weight at each inch in height (read the weight column vertically). On the other hand, weight for a given height varies little from year to year for the same period; however, after the eleventh year this increase is marked (read weights horizontally). These facts of normal growth of adolescent children make it impossible to express proper weight for height without taking into consideration the age factor. The average annual increment of the tables gives a general basis for comparison of growth of tall, medium, and short children.

The limitations of all growth tables should be recognized. They do not aim to present a complete clinical picture of a child's physical

condition. However, relation of weight to height and age is the best single index of general health and nutrition, as well as the best criterion of normal growth that we possess.

Pioneer Enquiry in Glasgow.—In 1906 an enquiry was con-

BOYS

HEIGHT – WEIGHT – AGE

AVERAGES IN MILLIMETRES AND TENTHS OF KILOGRAMS

BASED ON BALDWIN AND WOOD.

AMERICAN CHILD HEALTH ASSOCIATION

BOYS	7	8	9	10	11	12	13	14	15	16	17	18
1000	170											
25	174											
50	180	180										
75	190	190										
1100	201	201										
25	212	212	212									
50	221	221	221									
75	231	231	231	231								
1200	241	241	241	241								
25	253	253	253	253	253							
50	266	266	266	266	266	266						
75	278	278	278	278	278	278						
1300	289	291	293	293	293	293	293					
25	300	304	306	306	306	308	311					
50		319	319	319	320	322	326	329				
75		328	329	331	333	335	338	341				
1400		341	346	349	351	353	354	358	363			
25			361	365	367	369	373	376	381			
50			378	382	382	384	387	392	396			
75				398	401	403	407	410	412	417		
1500				413	419	420	422	427	433	440		
25					432	436	441	448	454	468	482	
50					454	458	462	468	475	486	505	527
75					476	478	483	490	499	513	533	553
1600						497	501	510	519	532	550	572
25						522	526	535	544	558	574	594
50							543	552	564	580	597	616
75							566	575	586	601	616	632
1700								597	609	620	637	649
25								619	628	641	654	669
50								642	650	660	670	683
75								669	672	678	687	696
1800									693	696	705	714

TABLE 11.

ducted in Glasgow, and analysed in the Galton Laboratory (*Report on the Physical Condition of Children Attending the Public Schools of the School Board for Glasgow*, by Dr. W. L. MacKenzie and Captain A. Foster. Wymans, 1907), and also in *Height and Weight of Glasgow School Children*, by Ethel M. Elderton (*Biometrika*, vol. x. Nos. 2 and 3, November 1914).

The Glasgow tables are not, unfortunately, in metric measures; but they give four social divisions, and can be compared among themselves. The figure shews how closely weight and height are related, compared with age. It is taken from the Glasgow enquiry.

GIRLS
HEIGHT—WEIGHT—AGE
AVERAGES
IN
MILLIMETRES AND TENTHS OF KILOGRAMS
BASED ON American Child Health Association Tables

GIRLS	7	8	9	10	11	12	13	14	15	16	17	18
1000	161											
25	164											
50	171											
75	180											
1100	187											
25	195											
50	208											
75	218	221										
1200	227	231	231	231								
25	238	239	239	240	243							
50	247	249	253	256	258							
75	259	261	266	270	277	284						
1300	273	276	279	282	288	296						
25	289	293	293	294	297	304						
50	298	304	306	310	311	315	322					
75		315	318	322	324	326	333					
1400		328	336	338	340	341	349	358				
25			349	354	358	361	367	387				
50			364	371	373	376	383	401	419			
75				382	390	394	400	421	437	455		
1500				397	409	409	420	437	455	469	478	
25				413	427	434	440	459	475	486	495	502
50					450	454	458	475	490	506	515	522
75					472	474	481	494	510	522	531	535
1600						494	503	513	524	531	540	544
25						515	522	531	537	544	553	560
50						534	541	546	552	557	566	571
75							557	566	571	580	584	589
1700							579	589	593	599	604	611
25							593	602	611	615	622	629
50								612	619	626	634	641
75								618	627	634	642	647
1800								625	634	642	650	657

TABLE 11—*continued.*

In any group average stature improves with the social stratum. Average stockiness as shewn by the W/H index does so too, but in this last regard, if children below mean stature are taken, the reverse holds. Probably they are not in such good health and form the tail of the group. This may also account for a Detroit Report (November 1922, p. 4) that the proportion with "Under-

weight is greater the higher the social and economic status of the population," suggesting this to be a statistical error based on reckoning weights for heights. Benedict and Talbot (Carnegie Inst. Publ., 302, 39) found their private school children taller and heavier, but lankier than ordinary.

Several writers on secondary schools speak of scholarship boys as smaller and physically more retarded than others. Possibly this is due to some financial regulations selecting those of a poorer social grade. The Terman classes (exceptionally bright) in New York are below average weights.

In the Glasgow enquiry children were also grouped according to the number of rooms occupied by the family. Selecting ages 5, 9, and 13 years, and for brevity taking children generally as given in the Report, we have—

TABLE 13.

GLASGOW ENQUIRY.

Number of Rooms occupied by the Family.	Heights in Centimetres.			Weights in Kilos.		
	5.	9.	13.	5.	9.	13.
1	99	118	135	16·87	23·31	31·70
2	101	121	137	17·64	23·08	32·79
3	103	122	140	17·91	24·85	34·15
4 or more	105	124	141	18·18	25·53	34·83

"The one-roomed child, whether boy or girl, is always on the average distinctly smaller and lighter than the two-roomed, and the two-roomed than the three-roomed, and the three-roomed than the four-roomed. The numbers examined were so large, and the results are so uniform, that only one conclusion is possible, viz. that the poorest child suffers most in nutrition and growth" (Report, p. 5).

Association between social level and physique, as measured by height and weight, shews wherever tested, as above, or in comparing secondary and elementary schools.

Supernormal Environment.—Josephine E. Young presented a Report (Buffalo Congress, vol. ii. p. 17) on supernormal environment in regard to certain Chicago children of richer classes. "The hygiene of the school is as perfect as equipment, science, money, and faithfulness can make it." Nursery maids and automobiles being the order of the day.

These children were taller and heavier, had greater vital capacity, lower blood pressure, and slightly less hæmoglobin than the Chicago secondary school child. They are the biggest children recorded.

A group of children who in some ways may be compared are girls of the North London Collegiate School. The averages from 1873 to 1909 were published by Dr. Julia Cock.

Lack of exercise seems the most probable cause of the great weight for height in these girls.

Feeding and national customs may affect growth considerably. In his book on *Food and Growth*, Emmett Holt discusses food of the Japanese as deficient in growth proteins and calcium, and possibly also in vitamin A. Although the diet is not completely altered, Japanese children born in America are, age for age, bigger and heavier than the children of Tokio. Again, American-born children of certain aliens run 4 or 5 inches taller than their Italian or Russian parents, except among the very poorest, where national habits and mode of feeding is generally retained; similarly, Robertson found

Table 14.

NORTH LONDON COLLEGIATE, 1873–1909. (GIRLS.)

Age.	Height.	Weight.	Index.
10–	134·6	31·3	232
11–	141·5	36·0	254
12–	147·3	39·1	265
13–	151·3	43·0	284
14–	154·4	47·8	309
15–	158·9	50·5	318
16–	159·9	52·8	330

Australian-born children of English stock heavier and taller than English children.

These physical measurements shew that the poorer the social rank more hindering to growth is environment. How much this is the cause can only be found by having a datum line. All kinds of hindrances have later effect on growth. Dr. C. J. Thomas shewed (*M.O. Ed. L.C.C. Report*, 1905) that years of high infantile mortality were followed by corresponding crops of under-height children (Fig. 8).

Wahl, who weighed the girls of a Danish residential school regularly, demonstrated that a whooping-cough epidemic was followed by much lessened growth, but later compensated, so that it was more than a year before they reached the weight to be expected if no epidemic had occurred. Malling Hansen also noted this effect of influenza.

Effects of rickets have been demonstrated by Dr. George Rose, and the following is compiled from his tables of 1914 and ten years later in regard to large numbers and the same children (Table 15).

Reduction of height and weight bears the same relative proportion at both ages.

H. P. Newsholme has obtained similar results in the North Riding of Yorkshire (1922).

Mumford, in a study of the past thirty-years pupils (*Physique of Modern Boy*, Manchester Lit. and Philos. Soc., 1912), finds : " That of every 100 boys at the Manchester Grammar School who are retarded one year or more in their work, 83 per cent. shew evidence of damaging disease in early infantile life." He shews physique, estimated by height and weight of the present generation, to be better than at corresponding ages thirty years ago. His results

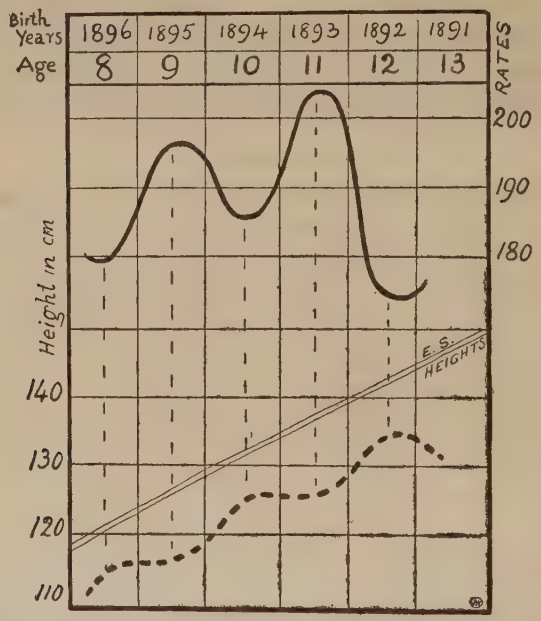


FIG. 8.—RELATION OF HEIGHTS (DOTTED) TO PREVIOUS MORTALITY RATES (THICK CURVE) IN YEAR OF BIRTH.

Annual normal heights double thin line (C. J. Thomas).

are confirmed by observations from Marlborough, Rugby, and other Public Schools.

Bertha Borung, comparing Jena entrants of 1880 and 1921, found considerable increase in height at the same ages, even at the start of school-life.

Improvement in growth of the present, as against the past, generation is marked wherever tested.

The most strenuously applied test is in the increasing weights of the oarsmen of the University boat crews. Tradition has it that the heaviest crew is likely to win. Since 1841 there has been a steady increase in the average weights for each period, and an average gain of a stone in the eighty years (Table 16).

Relation of Stature to Intelligence.—Presumably the better developed the body the better the function of its various organs. In nervous action, as shewn by progress in school, other things being equal, there is definite relation between school position and growth as measured by height and weight. It has been noticed by all enquirers.

TABLE 15.

ABERDEEN ELEMENTARY SCHOOLS.

	Boys.		Girls.	
	Height.	Weight.	Height.	Weight.
Age 5 years 4 months (1914)—				
Non-rickety	105·4	18·55	103·6	17·87
Rickety	101·3	16·65	100·3	15·74
Difference	4·1	1·90	3·3	2·13
Age 13 years 3 months (1924)—				
Non-rickety	142·75	37·19	146·3	37·65
Rickety	137·56	33·07	139·7	32·84
Difference	5·19	4·12	6·6	4·81

TABLE 16.

Crews of Periods.	Average Weights.
	st. lb.
1841–1857	11 5¼
1858–1867	11 8½
1868–1877	11 12¾
1878–1887	11 13¼
1888–1897	12 1¼
1898–1907	12 2¼
1908–1914	12 5½
.. ..	.. ..
1919–1925	12 6½

Porter, at St. Louis, published results of measurements of 33,000 children (*U.S.A. Educ. Rep.*, 1897–8. 1097), from which he deduced a physical basis for brightness and dullness. Precocious are heavier, dull lighter than ordinary. Mediocrity of mind is associated with mediocrity of physique. Porter concluded that comparative growth and acceleration preceding puberty in both boys and girls is the same in mentally dull, mediocre, and precocious. He put forward one recommendation, which is of importance

educationally: "No child whose weight is below the average for its age should be permitted to enter a school grade beyond the average of its age, except after such physical examination as shall make it probable that the child's strength is equal to the strain."

Gratsanioff, in Russia, had already demonstrated that bright

Table 17.

LONDON STANDARDS. HEIGHTS OF GIRLS AND BOYS.

Ages.	I.	II.	III.	IV.	V.	VI.	VII.
Girls							
14–	—	—	—	—	151·4	153·1	154·2
13–	—	—	136·8	142·8	146·2	148·5	150·8
12–	—	132·4	135·7	139·7	140·8	145·1	145·4
11–	—	132·6	131·1	135·8	138·7	138·9	145·0
10–	125·4	125·8	129·2	132·1	133·5	135·1	—
9–	124·2	122·3	126·3	129·5	130·7	132·0	—
8–	115·9	121·5	123·1	125·2	—	127·0	—
7–	110·1	117·0	117·3	120·0	—	—	—
Boys							
14–	—	—	—	141·5	148·9	151·2	152·5
13–	—	—	139·1	140·2	142·6	146·2	147·1
12–	—	130·3	134·7	136·0	139·3	141·6	142·7
11–	—	125·6	132·7	135·0	137·6	138·0	143·3
10–	127·3	126·0	130·0	131·2	134·0	134·4	—
9–	124·2	123·2	126·9	127·6	129·5	—	—
8–	117·9	121·4	123·9	127·0	—	—	—
7–	114·1	114·7	123·1	—	—	—	—

Table 18.

NORMAL AND DEFECTIVE LONDON CHILDREN.

Type of Child.	8-year-old Group.				12-year-old Group.			
	Boys.		Girls.		Boys.		Girls.	
	Height.	Weight.	Height.	Weight.	Height.	Weight.	Height.	Weight.
Normal	119·15	22·58	119·0	21·94	138·63	32·65	140·68	33·04
Mental defectives	116·00	21·80	116·2	21·80	134·90	30·27	134·20	29·72

pupils were larger than dull, and Sack, studying over 4000 boys, the majority of whom he measured twice, confirmed the result that brighter children have a larger chest girth and are taller than the dull.

The result of the first extensive London measurements demonstrated that height was greater, the greater the intelligence of the child as measured by school progress (Fig. 9).

Further details for 10-year-olds are given (*Report Med. Off. Educ. L.C.C.*, 1907. 15), where it is shown that correlation is high : Boys, $r = 0{\cdot}39 \pm 0{\cdot}02$; Girls, $r = 0{\cdot}52 \pm 0{\cdot}02$.

In Table 18, page 32, are given some recent massed figures for London, 1923, shewn for girls in Fig. 9.

As a by-product in the study of nutrition among 80,000 Detroit public school children in 1921, a preliminary study of weights shewed that at every age, weight and height bear a very definite relation

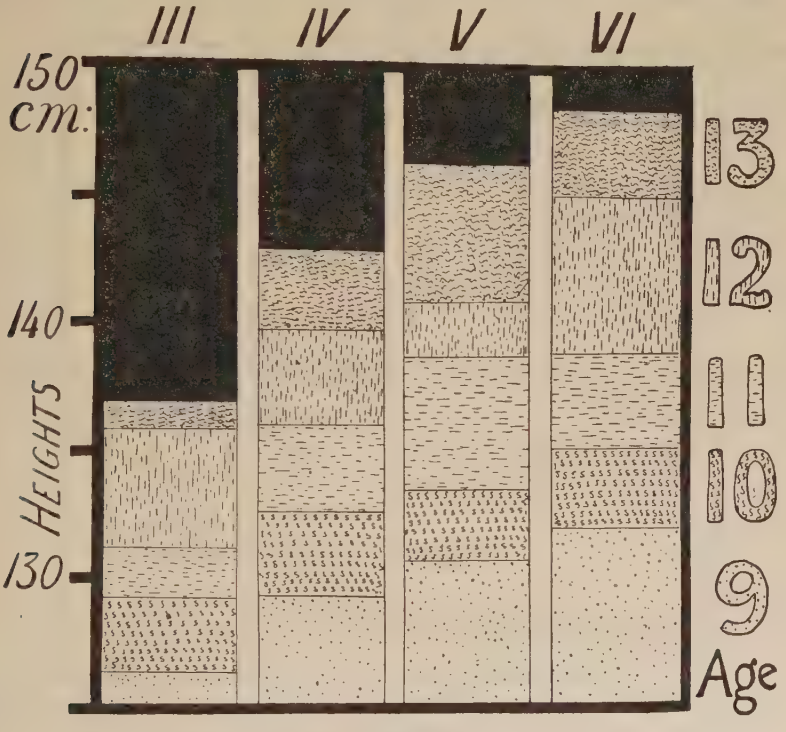


FIG. 9.—GIRLS' AGES, HEIGHTS AND STANDARDS.

To illustrate relationship of physique and mentality.

to school progress. Retarded children are generally shorter and lighter than children in grade at age. Accelerated children are generally taller and heavier than children in grade at age (Fig. 10).

The vital capacity has been studied by Mumford in about 4000 boys. He not only studies the whole, but also relative expansion of different parts of the chest, and finds that good breathing and good thinking are closely correlated, He is relying more and more on this as a test of efficiency and power during adolescence.

Stuart A. Courtois (*Am. Phys. Ed. Rev.*, 1917. 464) demonstrates a drop in attainment progress in school, coincident with increase in pre-puberal growth. He regards lung capacity as the

vital element in growth, and furnishes curves of theoretical growth in height, weight, lung capacity, and grip ; from 5 to 20 years, vital capacity increase apparently preceding other growth (Fig. 11).

Whilst development may have its influence on school, there is also a reciprocal arrest. Schmid Monnard gives rates of growth based on the same children followed from birth onwards. For the seventh year of life he found gains.

Garrison and Pullias (*The Psychological Clinic*, 1923. 259) tested a small number of bright children with intelligence quotient from

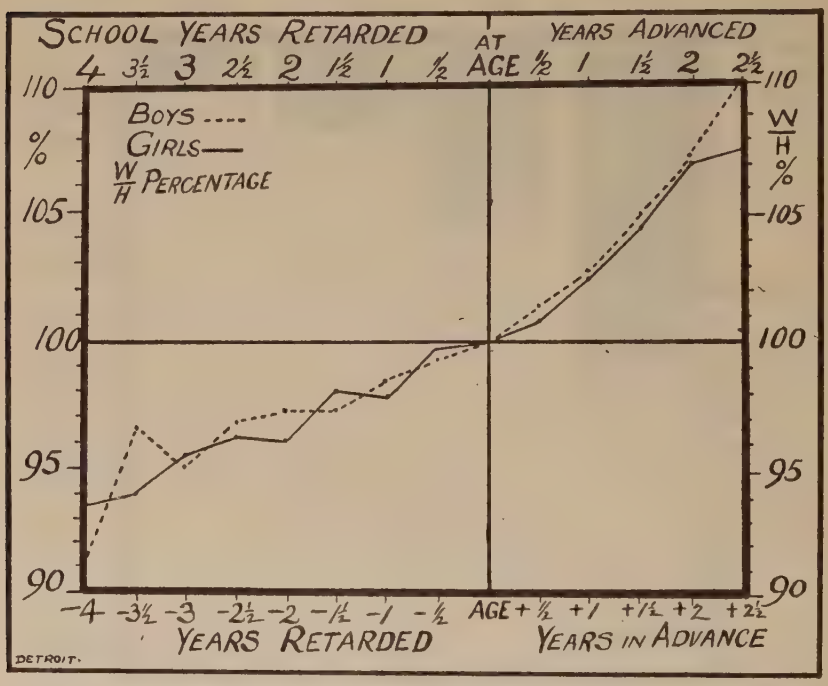


FIG. 10.—THE RELATION OF WEIGHT-HEIGHT INDEX TO SCHOOL PROGRESS.

116 to 170, when high intelligence was correlated intimately with power of hand grasp, height next, then vital capacity and weight least. The results shewed that superior mentality and superior physical development go together.

B. T. Baldwin formulates height, weight, and development of carpal bones as a satisfactory measure of maturity in the developing child, but goes beyond this and asserts that it is a measure of mental maturity and social maturity, and that maturity has a powerful influence on scholastic achievement. Probably if he said precocious scholastic achievement this would be beyond dispute. It has lately been disputed by Gates on the basis of measurements at Columbia University, and whilst correct in the mass, does not hold individually.

Seasonal Variations in Growth.—In observations on children's growth it is necessary to select children of about the same physique, and experience has shewn that the period of year must also be noted. There is a considerable seasonal variation to be discounted, or, as in the past, it may vitiate many conclusions.

A Report of Schanze on the entrants of a small Dresden school having lost weight in their first three months at school is given in Table 20. This loss is just what might occur at that season, so that it is quite inconclusive as to the effect of school entrance. Height is mostly gained up till August, weight after that. Sundry observations in North European schools had brought this out.

Wretlind, in Gothenburg, weighed school girls from 7 to 17 years old and found increase in weight in three Summer months

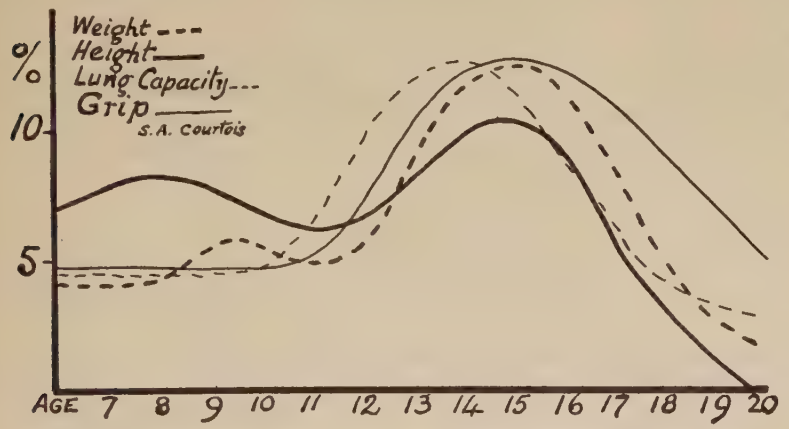


FIG. 11.—SCHEME OF RATES OF DEVELOPMENT OF BOYS.

almost as great as in the rest of the year. His observations were directed to school influences.

Wahl for nine years (1884) weighed the girls in a Danish high school in April and October, and found Summer increase 6·30 per cent. against the Winter 4·87.

R. Malling Hansen, in the Copenhagen Deaf School, weighed children daily, fifteen at a time, on a coal scale. His weighings went on for seven years. When influenza came (*Zeit. f. S.*, 1890. 65) the weighings were short for a month, only reaching two-fifths of what was to be expected. There was no other factor than the prevailing epidemic. He concluded that the body weight of a boy of 9 to 15 years old goes through three annual periods : a maximal increase from middle of August to middle of December (4½ months), a medium period till middle of April (and then 4½ months), and a minimal period from end of April till end of July. During the maximal period daily gain is three times that of the medium period,

and nearly the whole gain of the medium period is lost in the minimal. Heights follow inverse changes to weights.

Schmid Monnard (*Zeit. f. S.*, 1894. 626) studied growth of 190 children aged 1 to 12, gain was only from July to January, and from February till June no child gained a gram. This holds from the second year on, and school does not alter it. Variations shew more than in height. He concludes that for children loss of a half

TABLE 19.

HALLE CHILDREN, 1897.

Aged six years.	Weights in Kilos.		Heights in Centimetres.	
	Boys.	Girls.	Boys.	Girls.
Without schooling	2·2	1·9	7·4	5·6
With schooling..	1·5	0·6	4·2	4·5
School children less by ..	0·7	1·3	3·2	1·1

TABLE 20.

Dresden.	Forty-two Boys.	Thirty-seven Girls.
	Kilos.	Kilos.
Average weight on entrance, April 11, 1902 ..	18·748	18·178
Later, July 11, 1902	18·240	18·051
Loss in three months	0·508	0·127

kilogram in the first half of the year is not abnormal, but in the second half is suspicious of disease.

Recently in Jena (*Arch. f. Kinderheilk*, 1924) Hildegarde Frank shews that babies grow mostly in length in late Spring and early Summer. American observations also place increase in length as beginning in February, and still stand in Summer (*Pediatrics*, 1925. 272).

Godin sums the matter: "*Que l'hiver fait du poids, et que l'été fait de la taille.*"

Matthias (*Schweiz, Blatt. f. Schulges.*, 1915, February 17) observed the same variations, but also tried to relate them to bodily activities, as exercised students grew more in Winter than those unexercised, whilst in Summer growth was identical, presumably through outdoor games being nearly equal.

Open-air classes, when started in London, were only worked

from April to September, and gain in weight comparable with annual rate of gain of the ordinary school population was extraordinary, twice or thrice as great. "The enormous gain in weight is not a permanent increase, and is lost on ceasing to attend the school, with its rest and feeding" (1908).

When ordinary school children were used as controls over the same period of year, advantage of the open-air or playground class in this respect vanished. Indeed, reversing conditions at Shooter's Hill Open Air school, twelve children present through three successive years grew at the rate of 0·217 per cent. weekly the whole time, but thirty normal control boys in an East End school grew 0·326 per cent. weekly for 26 weeks, including Summer, the annual average being 0·185 weekly. It was also found that growth in

Table 21.

GAIN IN POUNDS' WEIGHT OF BOYS AND GIRLS BORN IN AUGUST 1905. (BOSTON.)

	1912–13.	1913–14.	1914–15.	1915–16.	Epidemic Year.	1917–18.	1918–19.	Average.	Ratio.
Boys—									
Sept.–Jan.	3·34	2·17	2·85	1·29	—	5·85	4·88	3·40	4·1
Feb.–June	+0·75	−0·17	+0·67	+0·81	—	−0·07	+2·9	0·82	1
Girls—									
Sept.–Jan.	1·88	2·50	2·96	1·63	—	3·19	4·63	2·79	3·9
Feb.–June	0·12	0·65	0·13	0·71	—	0·81	1·83	0·71	1

height was going on when weight was at a standstill, and then the whole seasonal variation became clear.

With seasons reversed, as in the Southern Hemisphere, growth follows. Dr. Jane S. Greig and various Australian observers note in school reports rapid gain in weight in children in March, April, and May. The gain begins in February, "one of our hottest months." Dr. Fitt, of Auckland, found that in Melbourne school children fatigue appeared to increase during the school year. The year divided distinctly, Feb.–July and Aug.–Jan., those seasons being the reverse of European. Increase in weight of 350 children aged 7–14 averaged 440 grams in first, compared with 127 grams in the second part. Individual variation was not less than 2 : 1, and in some 19 : 1. Growth in height was in reverse order, 0·38 mm. in first, against 0·46 in the second period, with greatest rise in August. Memory was least in August, and everything pointed to this as an unstable period mentally and physically (*Aust. Ass. Adv. of Sci.*, 1923. 704).

W. T. Porter has recently worked out seasonal variation in Boston school children (*Am. Journ. of Physiol.*, 1920. 121). He classifies children also by the month in which they were born.

He publishes the weights of boys born in 1905 distributed by months shewing seasonal variations in pounds. The average percentage gain (percentage for month on weight at beginning of month) for first five months was 1·89, for last five months 6·61.

In Nutrition classes in New York the results were inexplicable till this seasonal variation was shewn in 1920 by controls, who gained weight October to February, 47·5 per cent. of annual, February to June 28·7 per cent., and June to September 23·8 per cent.

J. C. Gebhart, from 977 individual records of New York children, gives the following as percentage weight increase of the year—

Table 22.

SEASONAL WEIGHT INCREASE.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	
Boys ..	9·9	7·6	6·4	4·7	3·7	0·9	3·9	13·2	15·0	14·8	12·3	7·6	100
Girls ..	8·3	6·7	5·6	5·3	0·8	0·5	5·4	12·3	16·6	15·6	15·3	8·4	100

He gives a table of expected monthly gain from birth to end of the sixteenth year ("A Nutrition Survey," G. B. Affleck, *Am. Phys. Ed. Rev.*, December 1923). There are several precautions to be taken in regard to selection of time for measurements.

Thomas (*L.C.C. Med. Off. Ed. Report*, 1905) measured crops of children diminished in stature according to the high infant mortality rate of their birth year (Fig. 8).

Combe, of Lausanne (*Zeit. f. S.*, 1896, p. 585), shews that the month of birth influences height, but not weight; children born in Winter short, in Summer tall. Combe's tables of measurements are translated in *U.S.A. Education Reports*, 1897–8, i. 1123.

If classified by month of birth, as is done by usual methods, half the children are measured at the period of rapid growth, and half at slow growth, when classed by months of age. This can be demonstrated by Porter's table (Table 23).

Ward Crampton records that growth change at puberty is most prone to begin in Summer. The period of still stand in weight, and period of most rapid growth in height, appears also to be the time when the body resistance is lowest; morbidity and mortality rates then are highest, and the various catarrhal diseases are all more prevalent. It is also the period when, according to Kemsies, the ergograph shews a greater increase in muscular capacity.

Wretlind noticed that curvature of the spine often starts in this still stand period. Hertzberg and Schiötz (*Lancet*, June 3, 1922. 1109), who followed seventy boys through twelve months' growth, found the most significant figure of their curves, declines imposed by school work at seasons when physiologically there should be rises. This fall of weight during term has often been noticed, but it is not clear that it is due to school work rather than school diet.

C. C. Hall, who has kept measurements of his scholars at Beccles for many years, notes: "(1) Little increase in weight is usual in the Summer term. Boys frequently lose weight during their Summer holidays at home. On the other hand, chest expansion, particularly in swimmers, shews great improvement. (2) The greatest increase of weight takes place invariably in the Autumn

Table 23.

BOYS, SEASONAL GROWTH.

	Age in Months.	Season.	Weight in lb.	Age in Months.	Season.	Weight in lb.
Born Aug. 1905 ..	112	Dec. 1914	59·96	118	June 1915	61·56
	106	June 1914	55·25	112	Dec. 1914	59·96
			4·71			1·60
Born Feb. 1905 ..	112	June 1914	55·75	118	Dec. 1914	61·17
	106	Dec. 1913	54·50	112	June 1914	55·75
			1·25			5·42

term, during the latter half of which the boys are perforce comparatively inactive, but lose a little of their fitness. The boys' apparent leanness at the end of the term is due to the fact that they are in excellent training, well bronzed, and clear eyed, with sturdy bodies and muscles."

Diurnal variation in growth is shewn mostly by sinking of the spine during the day. There is also loss of weight during the night, so that measurements should, for accuracy, be taken at a fixed hour. Failure to replace weight within twenty-four hours of its loss by exercise means overstrain (*Am. Phys. Ed. Rev.*, 1910). T. A. Storey measured seven individuals daily for seven years (*loc. cit.*, 1911).

Somatic or Physiological Age.—Whenever any physical quality is measured there is always variation about a norm, following the usual curve of error in distribution. Its range becomes greater with the age of the individuals, being about double at the end of

school life compared with the beginning. Distribution of boys in different forms of a school, as one passes up the school, will spread over 4 or 5 years of age, although they are all supposed to be of equal intellectual growth.

Children start off unequal at birth. Although about 75 per cent. will be within a pound of the average, there will be some as much as three or more pounds below, some as much above, and the average differs for boys and girls. Eruption of the teeth marks convenient stages of growth, but eruption of the first permanent one, the six-year-old, may be as early as $5\frac{1}{4}$, or as late as 8 years of age.

Crampton, examining a set of twelve-year-old boys, according to the number of canine teeth cut, found very considerable differences in measurements accounted for by difference in physiological age.

TABLE 24.

TWELVE-YEAR-OLD BOYS.

Number of Canines ..	0.	1.	2.	3.	4.
Cm.	135·1	143·2	143·2	143·9	146·8
Kilos	31·8	32·9	33·3	34·5	36·6

Wisdom teeth may appear at 18, or be delayed till 25 years of age.

The skeleton on which the whole body is built and knit together presents in ossification of cartilage a long graduated series of changes. Harvey, in his examination of Old Parr, reputed to be one hundred and fifty-two years of age, wrote down that the costal cartilages were not yet completely ossified.

Rotch, studying carpal bones (*Am. Phys. Ed. Rev.*, 1910. 396), finds development of epiphyses more in accord with mental development than even weight and height or chronological age. He has published a graded set of pictures of development (*Trans. Assn. of Physicians*, 1909). Girls shew precocity over boys, and this is especially demonstrated in twins.

Baldwin (*Physical Growth of Children*, 167) calculated correlations between height and area of carpal bones of older children of the order 0·76 for girls, and 0·87 for boys. The coefficient of variability for boys is more than twice that for girls. In disparate twins of the same sex there are considerable differences, and of opposite sexes the girl is far in advance.

The pisiform bone appears one or two years earlier in girls; in boys the earliest noted was 10 years 4 months.

Various parts of the body grow at very different rates and times. The cerebrum grows rapidly in weight till about 7 years of age, by which time it has reached within 3 per cent. of adult weight. Its organization goes on long after this age, however. The more precocious cerebellum is somewhat slower in late growth. The volume (cranial capacity) increases till after puberty.

The face grows in an irregular way, with periods of rapid growth, alternating with arrest. This was worked out by West on Massachusetts school children, and is shortly reported in the *U.S.A. Ed. Reports*, 1897–8, vol. i. 1100. He considers that there are three distinct periods in girls, the first ending about the seventh year. There is abrupt transition from one type to another. About 8 or 9 the widths shoot up to almost adult dimensions, and almost suddenly distinctive childish characters go, about 11 years of age, some being later. Then there is another period of growth, about 15. Boys faces grow more slowly. The cephalic index alters quite irregularly during childhood.

The heart grows rapidly in pre-school age, about doubling its volume between 18 months and 4 years of age. The vessels are relatively large, and its growth remains slow till about 11 or 12, when there is a fresh increase, terminating after puberty.

Roberts (*Lancet*, 1885. ii. 149) has compared relative physiological ages of boys and girls, and expresses it by superposing curves of growth in height. The diagram he gives considerably overstates his own facts. He makes the boy of 15 correspond to the girl of $11\frac{1}{4}$, whereas the point should be 13, when adjusted for equal heights.

Several writers have tried to analyse growths into rhythms. The work which has found most acceptance on the Continent is the classification of Stratz (*Der Korper des Kindes*, 1909, Dr. C. K. Stratz). He is rather imaginative in this work, dividing growth into—

1. Infancy (0–1 year).
2. Neutral childhood—
   (*a*) The first plumpness (1–4) (Erste Füllung).
   (*b*) The first stretching up (5–7) (Erste Streckung).
3. Bisexual childhood—
   (*a*) The second plumpness (8–10) (Zweite Füllung).
   (*b*) The second stretching up (11–15) (Zweite Streckung).
4. Maturity (15–20).

He sums his observations in the following chart, which is put here for reference, as his measurements are so often quoted.

The writer has not been able to find any support for these divisions from his own measurements. Dr. Poul Hertz, of Copenhagen (*Review Psychol.*, 1913), after analysing rates of growth from the works of Bowditch, Variot, Pagliani, Ranke, and his own

on Danish children, says outright that the Stratz classification is purely ideal and unsupported by figures. Carl Schiötz, discussing Christiana children (1923), uses the term "absolutely erroneous" for the Stratz selection of photographs.

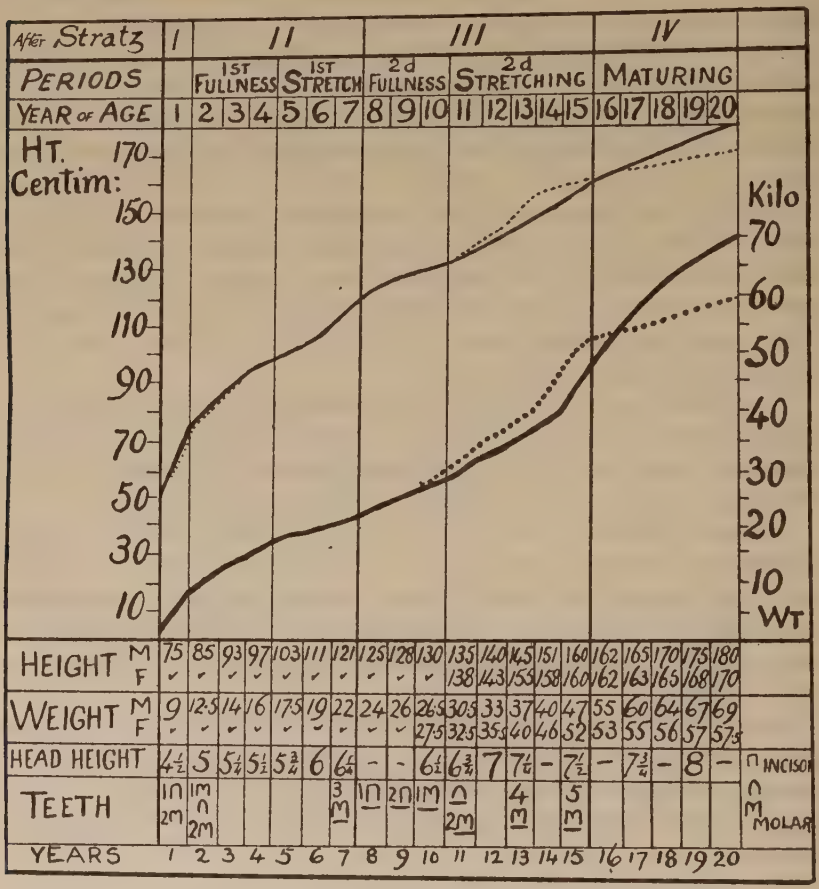


FIG. 12.—STRATZ SCHEME OF CHILDREN'S GROWTH.

Dr. Leon MacAuliffe, in *Development Croissance*, sets out stages of growth more rationally as—

First Childhood, 0–2½.—The body is mainly skull and trunk, with short limbs and much fat.

Second Childhood, 2½–6.—Mainly transverse growth, and growth of limbs. The plumpness remains.

Pre-puberal Stage.—A relatively short trunk develops from lengthening of the limbs, and the child becomes lean.

Post-puberal Stage.—Is where the individuality asserts itself, the common characteristics of a child disappearing.

Changes at puberty come nearly on completion of growth in

height, and are prepared for by a slight increase in rates of growth, in which girls from about 11 years of age exceed boys (Bowditch's law of growth). There does not appear to be any marked alteration in basal metabolism at this stage. Then there is almost an explosive change ; the pre-pubescent child, which has been losing its childishness in appearance, for a short time puts on weight, and there is considerable increase in basal metabolism. More food is needed than for the adult, and the child soon attains its full height. A child who has attained maturity is bigger and heavier than a child of the same age, which remains physiologically less advanced.

Ward Crampton gives the following figures--

TABLE 25.

AMERICAN CHILDREN.

Age	13.	14.	15.	16.
Weight, kilos—				
Immature	38·7	42·78	46·48	47·04
Mature	47·35	48·94	49·04	52·57
Height, cm.—				
Immature	146·8	152·6	154·9	157·5
Mature	150·6	154·7	155·0	157·5

Crampton notes (*Pedag. Sem.*, 1908) that the subcutaneous fat of the face and hands is chubby, more evident, and adheres closely to the skin, which also is of finer texture in the immature. In the mature it is firmer and thicker and less attached to the subcutaneous tissues which contain less fat. The pre-pubescent have no signs or development of hair, maturing have a fine and scanty covering, and mature have dense and coarse. Pubescence marks the beginning for a short time of a rapid increase in weight and strength, regardless of chronological age. This ought to be the dividing line as regards the legal entrance on working life. He gives extensive tables of measurements.

Davenport, studying inheritance (*Genetics*, 1917. i. 313), regards stature as made up of several segments. The variation of these excludes any simple Mendelian factor. The offspring of two tall parents is tall and less variable than offspring of two short parents also short. He attempts to assess body build, which he defines as chest diameter in relation to stature, but finally reduces it to weight divided by the square of the stature. This is already known as Kaup's index. For average male it is 2·52 and female 2·43, as they differ so little he does not distinguish sex. The values of the index in English measures are males $35·81 \pm 0·2$, and females $34·54 \pm 0·13$. He finally attempts to classify types.

So far physical measurements have been considered mainly as averages, but these averages are very rough groupings, and likely to err if there is not careful avoidance of selection by class or season. Roughly they are comparable against each other, it being assumed that other circumstances than those being assessed are equal.

Mumford (Manchester Stat. Soc., 1912) concluded that the most potent cause of backwardness was permanent influence on growth produced by past illness. He analysed measurements of height (2637) of deaf boys and (1741) deaf girls, the result of damage to the ears in early childhood, and found, in spite of superior care, that the deaf were retarded in all physical measurements compared with normals.

K. Kassowitz (*Z. f. Kinderheilk*, 1921. 30) shewed that proletarian children well nourished in an institution were bigger and stronger than might have been expected from their ancestry and *milieu*.

Merely comparing averages will give delusive results not purely due to statistical errors. In Reports of Medical Officers of Health, secondary school averages have been compared with elementary school averages to the apparent advantage of very inferior physique in the secondary schools.

"With the exception of boys aged 13 years, who are very slightly below the average, the weights of Blackburn scholars are in every case above the average, and the progressive increase in the case of the girls is remarkable." This is a judgment obtained by comparing secondary scholars with Arthur Greenwood's tables for elementary schools, whereas the measurements are really below secondary schools averages, and more than 10 per cent. below my suggested standards.

In others, Edinburgh for instance, age groups averaging several months older are compared with these anthropometric standards. Difference in the ages accounting for more than the difference in averages. So, too, Autumn measurements may differ from Spring. In the New York Nutrition classes (*Rept. of Bureau of Education Ex.*, 1922), where classes beginning in the Autumn had phenomenal success as assessed by weight gained compared with Spring classes, this was due to seasonal variation in growth.

The Sheffield Report for 1921 compares both elementary and secondary with the same "anthropometrical standards," thereby demonstrating satisfactorily that it is no standard.

The term "secondary school" requires defining. Torquay gives ages from 4 years old for secondary school measurements. No child under 11 should be in a secondary school. Indeed, it would be well for the country if no child under 11 was allowed to attend any educational institution other than the public elementary school.

It is sometimes hard to realize what an average means. The

average has to be considered in respect to σ, the standard deviation dealt with in the chapter on statistics. As Carl Schiötz points out, a curve of averages may be erroneous. The averages should be plotted, then, above and below each the probable error (p. 843), the two extremes being joined by a vertical line. A smoothed curve being now drawn evenly, but passing across some part of each of the various vertical lines, giving probable errors, is a better representation than the curve of averages.

An illustration may be given by taking Smedley's figures for Chicago boys (*U.S.A. Ed. Report*, 1902. 1095). By arranging

TABLE 26.

PERCENTILE GROUP. (CHICAGO BOYS.)

Age ..	4-	5-	6-	7-	8-	9-	10-	11-
Percentile Group.								
90–100	1165	1183	1289	1360	1382	1478	1479	1639
	1096	1124	1200	1248	1320	1369	1415	1452
50–60	1029	1090	1148	1200	1245	1299	1345	1389
40–50	1018	1079	1135	1190	1230	1285	1332	1378
	1010	1065	1123	1172	1216	1274	1318	1357
0–10	964	1030	1067	1125	1161	1214	1259	1291
	866	969	988	1036	1097	1072	1166	1131

Age ..	12-	13-	14-	15-	16-	17-	18-	—
Percentile Group.								
90–100	1613	1730	1763	1846	1853	1828	1839	—
	1507	1599	1666	1715	1750	1776	1814	—
50–60	1437	1505	1569	1629	1687	1711	1748	—
40–50	1421	1484	1550	1616	1672	1684	1742	—
	1403	1462	1523	1589	1650	1678	1720	—
0–10	1330	1400	1435	1493	1550	1604	1659	—
	1252	1311	1305	1323	1420	1376	1610	—

the cards of each age group in order of heights, then taking one-tenth of the cards away, the heights of the lowest and highest of this tenth gave the limits of the lowest percentile. The figures are given for the limits in heights, of the lowest tenth, the 0–10 percentile; for the tenth nearest to but below the average, 40–50 percentile; for the tenth nearest, but above average, 50–60 percentile; and for the highest tenth, 90–100 percentile group. The other percentiles are omitted to save space.

This shews the wide limits of height in millimetres included at each age by the average, and when it is set out on a diagram this becomes obvious.

This percentile diagram gives a clue to the average growth, and any child in a definite percentile who follows the trend of his group may be taken as satisfactorily nourished. If he improves he rises to a higher percentile; if, on the other hand, he sinks to a lower, he is going wrong. Weight, as already said, gives the quickest response to local or temporary conditions; on the other hand,

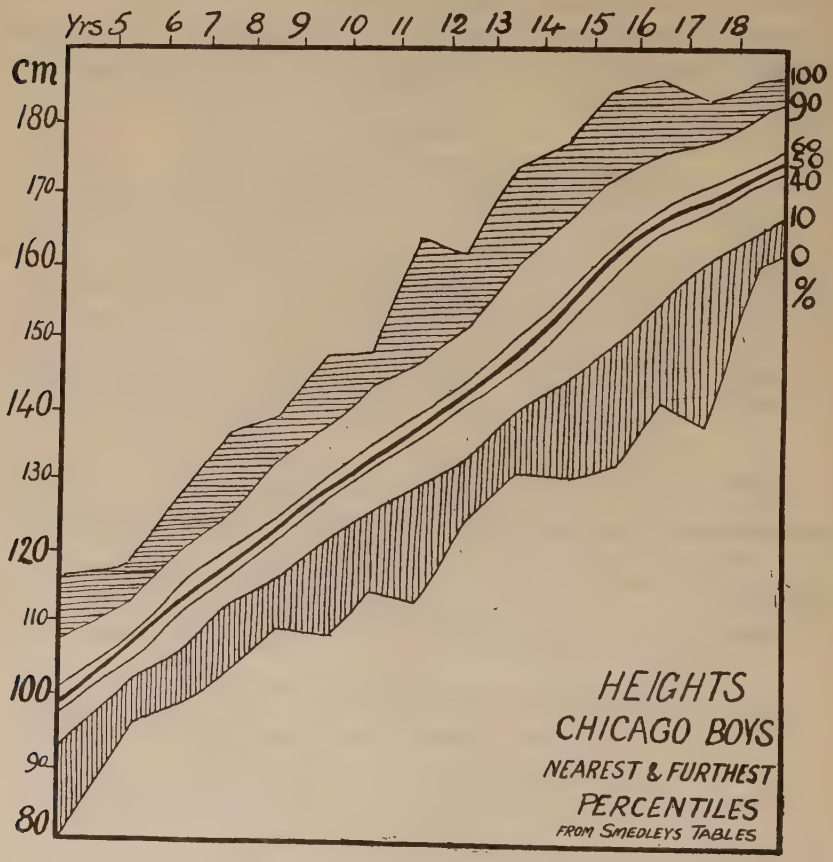


FIG. 13.—RANGES OF VARIATION IN HEIGHT.

height is the surest summary of the general vitality, summing the whole growth period. This method was set out for Haileybury boys by Hawkins in 1900, and has also been used by Mumford at Manchester as a most successful method of assessment. Baldwin and Wood used it in making their analysis into short, medium, and tall children (p. 24).

T. B. Robertson (*Med. Journ. of Australia*, 1922. i. 570), discussing normal growth of children, states that the criterion is the form of the growth curve rather than its deviation from any arbitrary standard.

Supernormality of weight may be negligible in comparison. He follows a similar method to that suggested above by drawing an average curve, and then drawing others differing from it by the variability of the dimension, which, in the case of stature in school children, is very low, roughly 5 per cent. Variability here being expressed by the percentage, the standard deviation is of the average value.

He therefore draws his average curve, and draws one 5 per cent. above and another 5 per cent. below it. On the ordinary theory of distribution, 68 per cent. of the children who will lie between these two upper and lower averages he groups as + 1, those below as — 1. Similarly, he forms by another pair of curves 5 per cent. above and below these, groups + 2 and — 2, there will be 13·5 per cent. + 2 and a similar number — 2. Outside these are 5 per cent. of children very large or very small + 3 and — 3 grades.

Average Heights.—In comparisons the wide range of averages themselves become obvious. For school boys of age 13 years last birthday heights in centimetres in so-called standards are: The B.A. Standard, 144·5, lying between Dukes's English Public School Boys, 151·4, and Tuxford and Glegg's E.S., 142·5. The highest measurements recorded are Baldwin's Chicago Boys, 153·0, and Josephine Young's ultra rich, 155·0.

Racial differences shew in Rhondda Valley E.S., 139·1; Gohlis E.S., 140·7; Japanese E.S., 141·5; Halle E.S., 142·0; Berlin E.S., 144·7; Secondary, 150·6.

If schools in the same districts are taken: Northamptonshire E.S. Urban 142·3, Rural 142·9, Secondary 150·8; London E.S. 143·1, Secondary 148·7; Manchester E.S. 139·4, Grammar School (1881–6) 146·7, and (1905–10) 149·6; Edinburgh E.S. 142·3 Watson's Second 155·1; Glasgow E.S., Poorest 138·5, Poor 139·4, Better class 142·5, Best class 144·5.

These are variations in Great Britain for boys of 13 years, giving averages from 138·5 in Poorest Glasgow to 151·4 in Public School boys. The British descendants in the Elementary Schools of New South Wales are equal in height and weight for age to the Secondary and Public School pupils of the Mother Country.

The averages mean different things in the precocious Jew and tardive Scandinavian, and it has been suggested that a better statement would be percentage of total growth attained by a certain age.

Averages used should be in reference to a common datum line so that comparison can be made by percentage defect or otherwise with this as standard.

Series of measurements can be arranged (*S.H.*, 1917. 101) in which there is a steady rise as one or other defective element in the environment is eliminated. If rickety children were excluded in

Aberdeen measurements, instead of boys of 5¼ averaging 102·1 cm. they would have measured 104·5 cm., an increase of 3 per cent.

Similarly, if conditions in the Glasgow poorest schools, where measures were 138·5 cm., had been raised to that of the best schools, they would have measured 144·5 cm., an increase of 4 per cent.

Secondary scholars exceed elementary scholars, age for age, by 6 to 8 per cent. Again, if improved conditions of early years to-day are compared with the past generation an increase up to 4 per cent. is observed, and still more is expected in future. If the effect of infectious disease is also discounted the standard

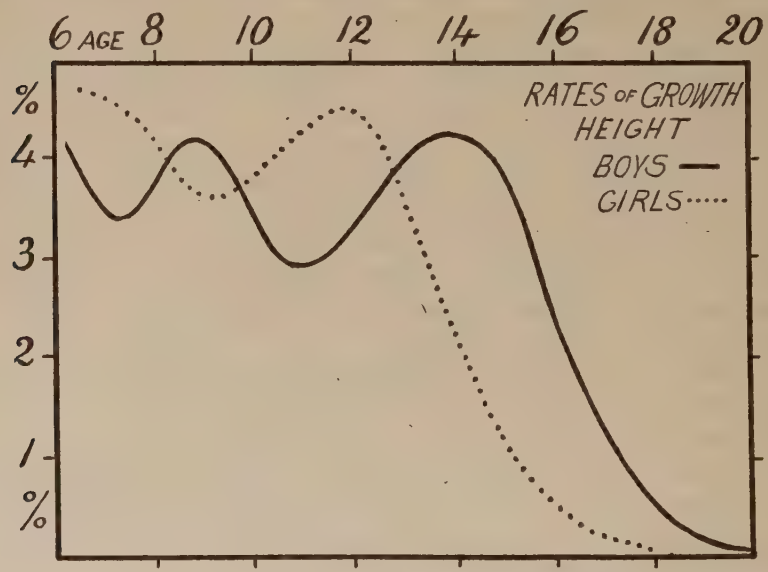


FIG. 14A.—AVERAGE RATES OF GROWTH, COLLATED FROM MANY RECORDED SERIES.

height of English boys lies between 5 and 10 per cent. above that given by Dukes for Rugby boys.

As a nation we should not accept quietly the difference in physical growth between primary and secondary scholars. We must make all our children pass into one national standard of physique, and no longer regard as inevitable, or the act of God, an inferior physique for artisans and superior for professional classes, knowing that although inferior heredity plays a part the difference is largely due to social failure to remedy causes within control, and therefore an index of national inefficiency.

A secure standard for reference values is therefore a necessity. Taking averages already given, tables can be set out in which each set with some improvement in environment presents figures a little higher, till the highest values shew us approaching an upper limit

which has not yet been reached. It is justifiable to speculate as to this limit. The author has put forward a tentative set of approximate standards for Anglo-Saxon children. The principles of seeking this standard have since been independently and exactly enunciated by Benedict and Talbot (*Metabolism and Growth*, 1921. 70). By comparisons with rates of growth these approximate standards have

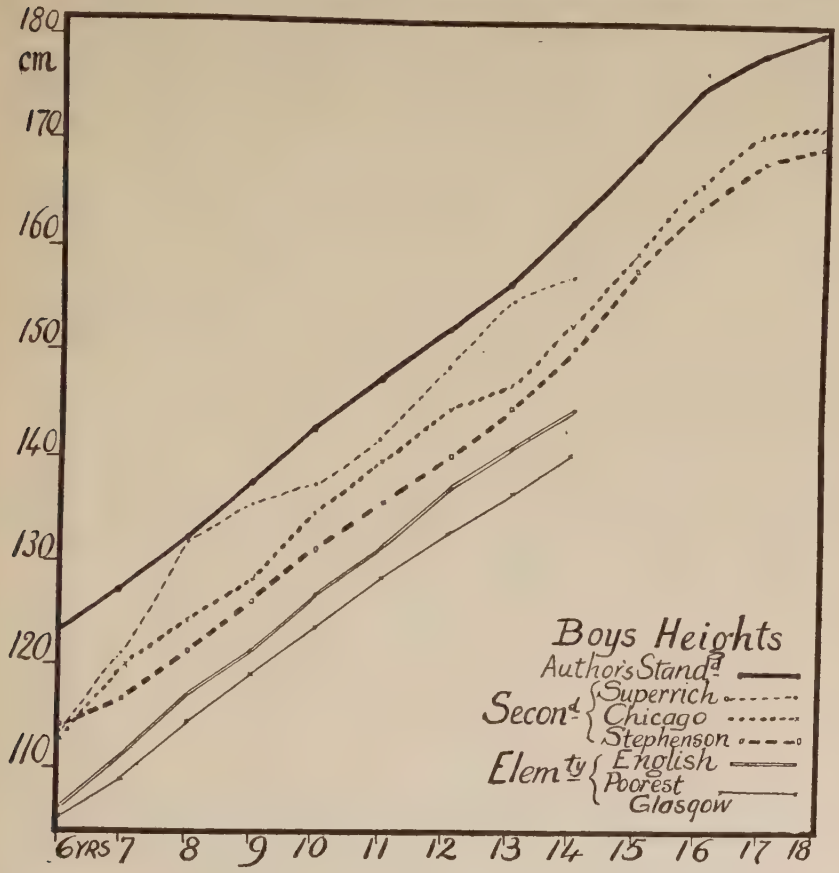


FIG. 14B.—VARIATION OF HEIGHT IN BOYS OF DIFFERING SOCIAL LEVELS WITH SUGGESTED STANDARD.

been adjusted as below. Heights are the most valuable, they are those below which any corrected standard will not fall. On the other hand weights should not be exceeded. These values are closely approached by measurements of Charterhouse boys and St. Leonards girls given in Pearson's Memoir on Temperatures (*loc. cit.*, p. 62). After Table 27 was written, 99 girls, aged 17 last birthday, were found in New Zealand, in the Otago High School, to average 166·2 cm. and 56·84 kilos, so that possibly the ideal has not yet been set high enough. In any

case it may be taken that these standards are a close approximation to what is possible. They would represent the ideal young Anglo-Saxon man as 6 ft. high and weighing 11½ or 12 stones; growth in height has practically ceased, whilst weight continues. That is what good environment, freed from all hindrances to growth, should do for our national physique.

The oarsmen of the Oxford and Cambridge boats 1920–24 had a mean age 21, weight 79·8 kilos, height 184·15 cm., and centimetre-gram index 433. They come up to the above ideal standard. Professor R. Tait McKenzie represented a typical American College athlete of 22 years, as 5 ft. 9 in. (175·26 cm.) in height, 159 lb.

Table 27.

KERR'S SUGGESTED STANDARDS.

Birthday.	Heights.		Weights.		C.G. Index.	
	Boys.	Girls.	Boys.	Girls.	Boys.	Girls.
6	123	120	25·0	23·0	203	192
7	128	125·5	27·0	25·5	211	203
8	132	131·5	29·4	27·9	223	212
9	137·5	136·5	32·0	30·5	232	223
10	143	142	34·8	34·7	244	244
11	147·5	147	37·9	37·8	257	257
12	152	153·5	40·9	42·5	269	280
13	156·5	160·5	44·9	47·5	287	293
14	162·5	165·5	49·6	54·2	305	327
15	169	169	55·3	58·1	327	344
16	175·5	170	63·2	60·3	360	355
17	179	170·5	68·6	61·9	383	363
18	181	170·5	71·2	62·2	393	365

(72·12 kilos) in weight and 40 in. chest. He is heavy and thick set compared with the suggested Standards, and his index is 411.

The advantage of such a Standard as suggested is that all other averages have at once a common measure of defect.

Setting out for a few years of age values of several averages already given, as taken from a chart at various birthdays, heights can also be stated as percentage defect from Standards.

The individual measurement has little relation to averages. The various indices suggested would ultimately give, if successful, a measure of specific gravity of the body rather than anything else. The only one of much practical use would be the W/H centimetre-gram index, and this rather in its rate of change than in any single statement. In fact it is found that in children who are adversely affected in life, when brought into good condition weight is proportionately greater than height. The poor children of Deptford

(Table 3) are stockier than Iowa children, who are much taller, and with whom they are there compared.

The only way in wide limits of health, in which measurements are useful to the individual child, is that they shall be so regularly charted that the child itself will know how it should be varying, and its rate of change can be watched. Any variation from the normal will then be noticed at once, and its origin sought. Single observations, or widely separated observations, are waste of time unless they shew such gross excess or defect that they must be pathological. This is rare, and should have had treatment long before.

A child may be in the 10 or 90 percentile group, or in Robertson's + 2 or — 2 group, differing widely from the average, and yet be developing healthily and normally. It really needs several observa-

Table 28.

COMPARISON OF VARIOUS BOYS' GROUPS WITH A STANDARD.

	Heights in centimetres.					Percentage below Standard.				
Actual Birthday	10.	11.	12.	13.	14.	10.	11.	12.	13.	14.
Kerr's Standards.. ..	143	147·5	152	156·5	162·5	0	0	0	0	0
Young's super rich ..	137·1	141·7	149	155	157·2	4·1	3·9	2·0	1·0	3·3
Chicago	135·9	140·3	145·4	150·2	155	5·0	4·9	4·4	4·0	4·6
Stephenson's Secondary..	131·5	135·8	139·8	145·0	151·4	8·1	8·0	7·7	6·8	6·9
Tuxford's English E.S. ..	127·3	131·8	137·2	141·0	144·3	13·8	10·7	9·0	9·9	11·2

tions to fix to which group it belongs, and that rate of change is normal.

Apart from this, the centimetre-gram index will be the best single indication of condition, but its rate of change is again the real test. It varies with season, during growth. The 7 per cent. below weight of the American nutrition workers neglects this seasonal variation, and merely by a rule of thumb skims off a more concentrated ill-nutrition group for observation, but misses some serious and includes some healthy ones.

The type of individual has to be taken into account in assessing measurements. It is here that clinical knowledge is of value. The Philadelphia Board expect their teachers to make the assessment. The physical type, whether heavy or slender, narrow or broad-backed, counts. These differences are noticeable before puberty, they are probably due to congenital conditions, but become more pronounced with growth.

The chief points for practical use on groups of children are—

1. Percentage defect from a datum should be used in comparisons.
2. Average heights are the best summary of life conditions.

3. Weight for height, rather than weight for age is the best index of present condition.
4. Somatic rather than chronological age should be used in any question of educational award or transfer.

Again, for the individual it is desirable to have—

(*a*) Recording of weight and height at regular intervals of not more than a month.
(*b*) Note of the centimetre-gram index as best indicator of condition.
(*c*) This index varies positively and negatively with season.

CHAPTER III

PHYSIQUE

The life of mind and body is so intimately related that we may talk about, but cannot conceive, one without the other. The nervous system in all its ramifications and stratifications is the master system of the body. Its activities are represented on one hand by intangibilities of the conscious and unconscious mind, on the other by chemical changes which result in production of various secretions, and ultimately in muscular action either voluntary or involuntary.

The noblest ideals, sublimest conceptions, and most matter-of-fact requirements, can only be expressed as a sequence of muscular movements. By physique is indicated a general conception of fitness in body mechanisms for their working under control of the nervous system. Good physique means life in its fullness in every tissue and cell of the body.

The life of cells depends upon metabolism of their protoplasm. In the final analysis it is chemical change. Some of the steps are different in different tissues. Particular bodies have been worked out as necessary for human life. Thyroxin, the chief essential of thyroid activity, is a necessity. So, too, is adrenalin from the suprarenal bodies. These have been isolated and then synthesized so that they can be built from their element without ever being part of any living cell. There are probably many more such bodies, like insulin, some known and some as yet scarcely suspected, which mould organs and control and influence bodily growth and action.

Muscular action is most obvious, the oldest recognized, and yet its fine details make up a secret and mysterious process ; and even structure of muscle fibre as yet eludes the microscope, although it is only through muscular action that our mind is evident.

Good physique is attained mainly as the result of exercise, whether that be from activities of living, or from formal processes of education. There may be active exercise from voluntary acts which are not purely voluntary muscular movements but willed actions. Action having been decided upon, the rest is left to mechanisms which arrange time, and co-ordinate a variety of muscular movements to produce the effects required. This is the best kind of exercise physiologically. For most of these muscular

movements we can take no credit ; they were acting to perfection in our ancestors ere the human race had appeared on earth.

Another aspect of exercise is passive movement, which has an important mechanical effect in promoting supply and removing waste. A certain amount of this takes place in all actions. Another effect that is often forgotten is postural tone ; a constant, slow adjustment by movements which are not noticeable, so that various parts of the body maintain their position relative to each other—contractile tone—and also tend to remain as they are—plastic tone.

If the teachings of comparative anatomy be followed, it is seen that the body has been profoundly modified to assume an upright posture. Ancestors of the human race were four-handed tree-dwellers, with more or less horizontally carried bodies, who in process of time took to the land and assumed an upright posture of body. Whilst some races retained much use of the upper limbs, the human branch developing its brain, hand, and eye mechanism fully, used legs alone for progression. The whole spinal and pelvic structures were altered, so that the pelvis is now sole support of the body, which has become exceedingly flexible in the upright position, to give free play to the arms.

The highest type of attitude is this human position, with upright body and head well balanced on the spinal column. The chest has become expanded laterally to give flexibility and good balance, the ribs acting as wide levers. Keith points out that whilst in all animals below man, shoulders and arms serve to support the body, in man, it is the body which supports shoulders and arms. This upright attitude expresses the acme of nervous development. The extensor muscles are those chiefly developed for this power. Any falling away from this position, even slight failure of full powers of the extensors, results in attitudes expressing feebleness, and characteristic of lower mental and nervous development, the attitudes, too, of old age.

Posture, then, is an indication of nervous condition to which the greatest value is attached, and full extension of the body is the human trait.

Breathing is perhaps most fundamental of movements. No one lives for five minutes without breathing. Vital Capacity is the volume of air which can be expelled by forcible expiration after maximum inspiration. This volume is proportional to oxygen intake, and hence to rate of metabolism, and is therefore in some measure an indication of physical efficiency.

Capacity to do muscular work depends on power of the nervous system to set muscles into action. This may fail from exhaustion, or fatigue, of either nerve or muscle cells. To prevent failure a constant supply of the oxyhæmoglobin nutrient material present in freshly oxygenated blood is required, and also constant removal

of toxic products of activity of muscle or nerve cells. The supply of sufficient blood depends on capacity of the heart to drive enough to the muscles, and its quality depends on power of the lungs to keep it aerated.

Blood which brings oxygen to every remote cell, there exchanges this for carbon dioxide, which is then conveyed away. Other products of metabolism are mainly removed through the intercellular fluids. This is taken out by lymphatics, passed through lymphatic glands, the detoxicating mechanisms of which destroy offensive or dangerous materials, and then purified lymph is returned through the thoracic duct to the blood.

Sufficient regard does not seem to be paid in teaching to the necessity of good lymphatic circulation in the prevention of fatigue. There is no lymph heart, but lymphatic vessels with their numerous valves constitute a feeble circulating apparatus, and maintenance of this circulation is dependent on sufficient exercise of many parts of the body. Every muscle during activity acts as a kind of accessory lymph pump, and also an accessory heart, in promoting blood circulation.

Failure to get sufficient exercise gives the type of flabby child a low vitality, subject to catarrhs and bronchitis, the type of child which one associates with the workhouse, or with the child too respectable to be allowed to play in the street.

Physical efficiency, then, in higher animals is maintained by efficient respiration and blood and lymph circulation, best developed and aided by physical movement and exercise.

In the case of a class of boys who had had little exercise, the writer found that gain in range of movement of the chest as shewn by difference in its circumference was 3·5 cm.; but only 0·5 cm. was increase in power of filling the chest, real gain being in power to empty it.

The fit individual is possessed of good vital capacity, mainly because he has power of emptying his lungs adequately by expiration. Free movement of the whole chest is necessary for good physiological effects. Much discussion has taken place on upper chest breathing and abdominal breathing. The former is a comparatively late development according to Keith, and only becomes chief when abdominal breathing is restricted, as in some forms of women's clothing.

"We have never yet found a small subcostal angle in a woman who has, as a result of her own labour, achieved success of a definite and objective type," is an American experience (H. McKinstry, *Am. Phys. Ed. Rev.*, 1922. 415).

The beaux of a century ago, with tight clothing and stocks, depended much on the upper thoracic breathing, and, as pictured, had over-inflated emphysematous chests with limited and scanty

powers of expiration, and were wanting in reserve from this cause.

Mumford, from his long experience at Manchester Grammar School, bases his estimate of a boy's general school capacity largely on his chest growth. After learning from a comparative study of the movement of various chest regions by means of registering tambours, he now trusts entirely to his own educated feeling when the flat hand is placed on the lower thorax, just above the diaphram level, and from about mid axillary line backward. He estimates good movements of the diaphram as the most important factor (*Lancet*, 1922, i. 478).

Tait McKenzie (*Montreal Med. Journ.*, April 1904) distinguishes two types of chest: a broad, flat thorax, type of the vaulter, jumper or hurdler, and a barrel-shaped thorax, type of a wrestler, swimmer, and fighter. The one has depth 1·4 in. below, and breadth 1·1 in. above the average; the other exceeds in depth 1·1 in., and the breadth is half an inch less than average. He uses an index, measuring the quiescent thorax at nipple level with relaxed muscles.

$$\frac{\text{Depth} \times 100}{\text{Breadth}} = \text{Thoracic Index.}$$

Five hundred McGill students gave this index 68, his ideal athlete (p. 50) was 68·6. Yale students were 69, Greek statues are all over 70, the Discobolus 71, Hermes of Praxiteles 79. He thinks Anglo-Saxons are of flat, broad type. Greeks and Italians tend to deep type.

The measurement of chest girth is not often done in ordinary school inspection.

Vital capacity, first proposed as a valuable clinical observation by Dr. John Hutchinson in 1846, has been used by Dreyer in recent years (*Lancet*, August 9, 1919). He compares the experimentally determined vital capacity measured with a spirometer, with the vital capacity as calculated from the individual's physical measurements. A series of carefully checked formulæ are utilized (Hobson, in *School Hygiene*, 1921, p. 8).

(i) $$\frac{W^{n_1}}{V\,C} = k_1$$

where n_1 is equal to 0·72 and k_1 works out about 0·69.

(ii) $$\frac{\lambda^{n_2}}{V\,C} = k_2$$

where n_2 is 2·26 for males and 2·3 for females and k_2 is approximately 1·9.

(iii) $$\frac{Ch^{n_3}}{V\,C} = k_3$$

where n_3 is 1·97 for males and 2·54 for females, and k_3 about 1·84.

(iv) $$\frac{W^{n_4}}{\lambda} = k_4$$

where n_4 is 0·319 for males and 0·313 for females, and k_4 about 0·449.

(v) $$\frac{W^{n_5}}{Ch} = k_5$$

where n_5 is 0·365 for males and 0·284 for females, and k_5 is 0·457.

W being weight without clothes, in grammes ; λ the stem length ; and V C the vital capacity. Ch is the circumference of the normal chest in cm.

Tables for assessment of physical capacity have been published by Dreyer, with these values worked out, so that the calculated V C can be found readily. The best way is to find vital capacity in terms of stem length, then in terms of chest circumference, and then average them. The physical fitness is stated as the percentage, the spirometer determination gives to the calculated capacity. The methods are probably of more value in following out variations in an individual than for general application. It seems at least doubtful, whether there is any greater usefulness for school purposes than in the application of, say, Kaup's index, $\left(\frac{W}{H^2}\right)$.

Mumford and Young have published (*Biometrika*, XV. Nos. 1 and 2) a paper on the study of the measurements of 1100 boys at Manchester Grammar School by correlating them with vital capacity. They find stem length to possess no advantages over stature, and that a power formula such as Dreyer's has no particular advantage in accuracy of prediction over an ordinary regression formula. The range of variation within physiological limits is so great that it is difficult to fix any deviation which may be considered reasonably to differentiate normal from abnormal.

Spirometry.—Almost all school children use the spirometer well after a single demonstration. The child should be seated, and, taking the deepest breath possible, blow into the spirometer until it has expelled the utmost possible. Care should be taken that the child does not fix its chest by trying to blow too hard, and also that it does not remove the spirometer mouthpiece before it has finished expiration. The best of three attempts is recorded. It is not sufficient, however, to record the vital capacity as merely a number of cubic centimetres, it has to be stated in relation to age and development of the child.

Dr. May Wilson (*J.A.M.A.*, April 15, 1922) has published a chart of the relations of vital capacity to surface area. For children from 6 to 16 years of age, it runs to 1·93 (boys 1·99, girls 1·88) litres per square metre of surface areas given by Dubois formula (p. 97), with a normal variation of 10 per cent. ; that is, between 1·74 and 2·12 litres per square metre of surface.

Another indication she suggests is that vital capacity is about 15·5 c.c. for each centimetre of height. Boys shew 6 per cent. greater capacity than girls ; activity appears to be the chief cause of variation, which otherwise is unaffected by ordinary malnutrition, poverty or social status. Under-weight children tend to higher values up to 2·0 litres, over-weight to lower, 1·75 litres respectively ; but this means little, as normal values are obtained when it is related to weight. A reduction in vital capacity of 15 per cent. from the normal for the individual suggests need for further careful examination of the chest.

The best form of spirometer is that in the form of a gas-meter, by Boulitte of Paris, but good work can be done by cheaper and simpler forms of wet spirometers.

In respiration, as in all vital functions, there should be considerable reserve powers, but many city-bred children grow up with scanty capacity, owing to want of exercise needed to develop it.

The day on which this was written, the writer refused to pass three lads of 16 as suitable to train for teachers. They were long and lanky, but their chest measurements only varied between 71 and 79 cm., at least 10 cm. too low. For some years these lads had played no games. For them teaching as an occupation would almost spell tuberculosis.

It is comparatively easy to blow out a boy's unexercised chest by a few days of exercise directed to this end, but it is of very little use unless actual muscular demands occur for increased supply of air. Mere deep breathing without any physiological demand is more likely to be harmful than otherwise. One of the first medical cases seen by the writer was a German youth who had landed with a brass band at Harwich, and proceeded to blow himself through the land. When Cambridge was reached a few days later, he had to be warded in Addenbrooke's Hospital with acute emphysema. Similarly, an enthusiastic teacher of one of the deep breathing classes mentioned, before much was known of this work, blew himself out so that he had to be absent from his work for many weeks with an acute emphysematous attack.

Deep-breathing exercises for children are in themselves enormously over-estimated. There is little to recommend them beyond their use in directing children to keep their mouths shut, and to use their abdominal muscles in breathing.

When medical inspection was almost isolated work, young children were often found who gave crepitant sounds along the front edge of their lungs. These signs were taken to indicate want of expansion in active exercise. Hundreds of playgrounds are wanted for children of London and all large towns to provide opportunity for chest expansion in free play with a good many sprints of violent effort. This is one of the neglected moves against

tubercle. Arm movements of an almost passive character may raise the ribs, but are of little physiological use compared with violent movements of play and Nature's adjustments.

As important, perhaps, as any deep-breathing effect, is use of these exercises in testing permeability of each nostril. Handkerchief drill should always precede deep breathing in children under 10 years of age.

Teachers are sometimes heard to say, "I want to see the chest rise," but maximum expansion should be about the central diameter of the body. This is a line running round the body about two fingers' breadth below the tip of the sternum. A full expansion at this level involves a lateral movement of lower ribs and also a descent of diaphragm, pressing slightly forward the upper part of the abdominal wall, within the arch of the ribs. At the upper part of the chest expansion is normally slight, while the lower part of the abdomen should not be protruded. Therefore, in indicating the desired movement to a class, the parting of the teacher's hand sideways is better than the raising of a hand. The raised hand may tend to suggest the raising of the children's shoulders ; or the lowering of a hand may suggest a low abdominal distension.

Children must avoid strain of any kind, lifting shoulders, or stiffening of abdomen, or any kind of noisy breathing, or facial or other contortions. The teacher must not make violent hand signs, and must avoid harmful instruction to hold the breath. If children realize the expansion of the central diameter, by placing their hands on their sides, they can then breath slowly, quietly, and deeply, in and out through the nostrils with advantage. If, now, the children with erect heads and raised elbows clasp their hands behind their heads, abdominal or diaphragmatic action carries on the breathing with advantage to singing and voice production later.

The normal ratio of inspiration to expiration is about 5 to 6. The apparent resting period of expiration is perhaps one-fifth of the cycle, but quite variable. The normal respiration rates are 17 to 20 a minute. Inspiration rates in exercises should not be too long, 5 to 10 seconds. With long, slow inspiration and expiration, there is nothing to be gained. In choir boys, for instance, practising slowly up to 50 or 60 seconds, hæmoptysis is not unknown.

Exercises like these will expand margins and bases of lungs as far as mere expansion is concerned, and make them available when the demand for sudden and sustained muscular action calls for a rapid supply of oxygen to the blood.

It must be insisted on, again, that any exercise making the children hold their breath at the end of inspiration or expiration

is wholly bad. Many a child in the infant school has a very sensitive heart, readily dilating on any extra call, such as repeated holding of the breath. Others than infants should practice these exercises. Once when some foreign inspectors were seeing work in a London school, on asking for breathing exercises in a Standard III girls' class, the astonishing answer was, "They do not know any, they are only done in the infants' department."

Probably exercise for inflation of lungs is most wanted at the developmental age of puberty, but it is physical exercise generally that is really needed, and subconscious rather than conscious adjustments and movements. Where children are kept bent over books, some counter action to the attitude of flexed chest is wanted.

The closed mouth has not been sufficiently noted, as for musical purposes children are often mistakenly told to exhale through the open mouth. All vigorous exercises should be done with mouth closed; it is only in utmost efforts to the limits of capacity, when accessory muscles of respiration are called into action, that gasping open mouth occurs. An open mouth should be taken as an indication of exercise beyond reasonable efforts in a school child, or that the child requires treatment for nasal obstruction, or possibly teaching is defective. In younger children, where such obstruction exists, attempts at nasal breathing may be ineffectual, and in many cases it is demonstrated that the chest walls give, in young children, as shewn by the so-called Harrison's groove down each side of the sternum when the rib cartilages have yielded in a rickety infant during whooping cough or catarrhal disease.

With an obstructed nose, then, attempts at breathing exercise with closed mouth may do harm, so that it is needed again to insist on free nasal breathing first, or no deep-breathing exercise. The "sneezing classes" urged by some extremists have a rationale of truth in them, and will be discussed in connection with nasal obstruction from various causes such as adenoids.

The Diaphragm.—At least one-third of the power in respiration comes from action of the diaphragm and its supports. Some points of this move vertically, through four or five centimetres, in the adult. Röntgen rays shew that this forcible action, where the abdominal viscera act like a piston, is largely dependent on power and strength of abdominal muscles. At each stroke, too, the liver, like a sponge, has the blood squeezed out into the great veins.

Deep breathing, taken after Swedish exercises to quieten the heart, probably has its effect, not in the removal of carbonic acid excess alone, but also in aiding the venous flow into the heart, through diaphragmatic action. Comparative anatomists tell us that the diaphragm was originally an accessory to blood circulation, but now it has been modified to assist respiration. For its full

effect to have play here, it has to be backed up by the power of the anterior and lateral muscles of the abdominal wall, so that in the end good respiration means efficient abdominal muscles.

After long-continued, heavy exercise, the diaphragm will be found to be raised as much as half an inch. One of the most useful tests, introduced into Air Force work during the War by Martin Flack, measured the endurance of respiratory and abdominal muscles. The nose being clipped, a mouth piece is blown into. It is connected with a U tube containing mercury, and the measure of endurance is the time a difference of pressure of 40 mm. of

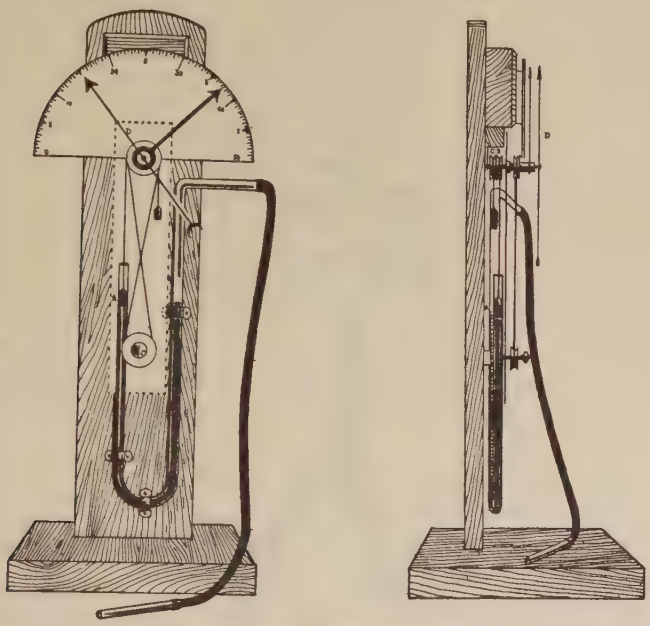


FIG. 15.—APPARATUS USED IN TESTING RESPIRATORY ENDURANCE.

mercury can be kept up. The standard for this in the case of the Air Force candidates was over 50 seconds. Mumford has adapted this for school-boys, using a pressure of 30 mm. as test, and for younger boys 20 mm.

By adding the mechanism of the ordinary barometer—a weight on a silk thread working over a pulley to which is attached a pointer moving over a scale—the movement of the mercury is magnified ten times. The child can see his effort, and keep the hand steady to an indicated position. His power of holding on is then measured with a stop-watch. This has been suggested as a less massive method of measuring the degree of general fatigue than other methods.

It also measures in some degree the mental determination as

well as physical power to endure. An account of its variation in the same boys over months, is given by Dr. Boome in the *Journal of School Hygiene*, 1924.

Capacity of aerating the blood is combined with supplying of this aerated blood to the tissues. The detailed mechanism cannot

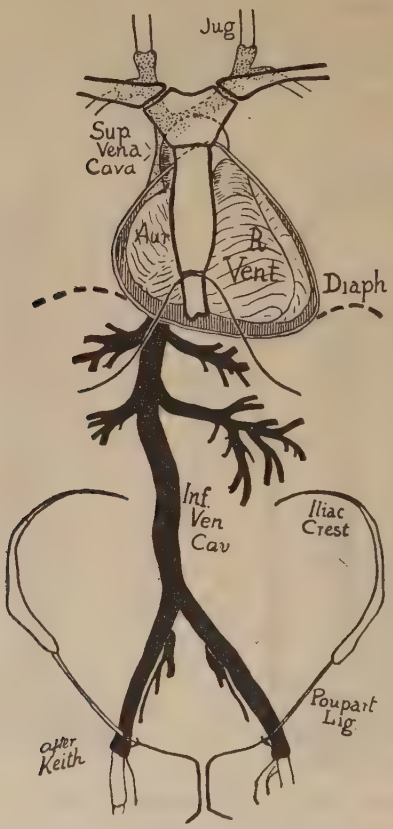


FIG. 16.—VENOUS CISTERNS FROM WHICH THE HEART IS FILLED.

Above diaphragm stippled, below in black.

be gone into here. The immediate response to muscular action is a determination of blood to the muscle in action. Dilatation of the vessels, then alteration in pressure and response of heart are almost simultaneous.

The whole question of response to effort is closely related to that of fatigue products circulating in the blood.

First, they stimulate the respiratory centre, causing quicker and deeper breathing. The increased respiratory movements raise

intra-abdominal pressure and facilitate return of blood from the great veins of the abdomen.

Now concentration of fatigue products is highest in the acting muscles, and has definite effects. A dilatation of local vessels occurs, which determines a greater volume of blood to the muscle in action. At the same time, increase of lactic acid and high carbon dioxide tension in the cell fluids favour a rapid dissociation of oxygen from the oxyhæmoglobin of aerated blood.

Weak respiratory movements produce many ill effects : among these is stagnation of blood in the great veins of the abdomen, which in adult life may lead to varicose veins and hæmorrhoids. Respiratory and circulatory response to effort, then, are the best evidences of physical efficiency, but there is also the mental factor, the will to do, and the determination to succeed, which is necessary to produce the maximum effort.

In extremity of effort facial expression is determined by urgent breathlessness calling all accessory muscles into action. Somewhat similar expression is brought in extremity of rage, when a snarling appearance about the mouth, and half-closed eyes probably meant the same thing—readiness for urgent respiratory effort and preparation to protect the eyes from the effect of raised blood pressure. Tait McKenzie has dealt well with the subject in *Journ. of Anat. and Physiol.*, xl. 51, and has modelled expressive masks of the different effects of physical effort.

Tests of efficiency as applied to R.A.F. pilot candidates form most instructive demonstrations of the value of these factors. They may be summed as—

(1) *Breath holding.*—After taking a deep breath, the breath should be able to be held for at least 34 seconds without sense of dizziness or mistiness before the eyes, or the candidate is unfit to fly at high altitudes. This measures respiratory reserves.

(2) *Expiratory force.*—When tested should reach at least 110 mm. of mercury. This measures the muscular power of abdominal and expiratory muscles.

(3) *The persistence test.*—Maintaining an expiratory force equal to 40 mm. of mercury for 50 seconds or more. Pulse rate will be found steadily rising during this time. This tests the reserves.

(4) *The pulse rate.*—Before and after exercise. The exercise used in the Air Force was to step up on a chair and down again five times in 15 seconds. Pulse rate should not rise more than 20 and should return to normal in 20 seconds.

(5) *Ability to hold* the breath for 50 seconds after exercise.

(6) *The vital capacity* measured with the spirometer should be at least 3800 c.c. for an adult man.

These Air Force tests have been applied to women by Dr. Lucy Cripps, who found women scored less than men in all tests.

Well exercised physical training pupils of the South-Western Polytechnic did much better than the students at Bedford College

in Regent's Park, who still led active lives, and they did better than the sedentary Civil Servant women of the Post Office (*Medical Research Sp. Report*, No. 84).

Pasmore and Weymouth, in the Stanford Laboratory, got similar results and gave the ratio of vital capacity to surface area: Men, 2·531; women, 1·757.

The more that is known of living things, the more evident it is that vitality consists in maintaining an ever-changing whirl of infinitely small variations in the conditions of each cell, yet always tending to normal condition. All the mechanisms of the body strive everywhere and all the time to keep up the minimum amount of variation from this optimum condition for the cell. In exercise, therefore, whilst promoting these changes, the body should always quickly revert to the normal.

The will to do has been referred to as an important factor, but one should go beyond this and say the reflex automatic action of the nervous system generally is equally important.

The muscles are kept in their normal relationships by a constantly varying flood of nervous stimuli to effect tone and balance. The upright position is thus maintained by continuous tonic reflex actions from the cerebellum in response to stimuli from muscles and tendons, vestibule and labyrinth, and as regards balance, from the eyes also. Postural tone is maintained through long periods without much fatigue, but it depends on the general health of the nervous system. The erect posture is essentially a powerful extension against gravity, and for ages it has been recognized that good physique shews in an erect attitude, upright, not bending at the knee. Efficient posture, indeed, connotes, as Æschylus understood, a well-poised body and mind. It is not merely a gymnastic matter but is fundamental in respect to fatigue, nutrition, and the emotional conditions which are life itself.

Tone of abdominal muscles materially supports the mechanisms by which abdominal breathing aids respiration and circulation. It also serves to maintain the viscera in their places. It is supposed to be maintained through varying pressure on sensitive structures in the Pacinian bodies found about the roots of the mesenteries.

In a decerebrate animal, whose higher brain has been separated from the rest of the spinal cord, spasm of the muscles shews that tonus arises from muscles, not from brain, and it is mostly the antigravity muscles which shew this. The flexors do not have it. The attitudes of the head have a great influence, as shewn by experiments on decerebrate animals, the posture tone being contributed to, by balance of fluids in the labyrinth, and as reflexes from the neck muscles. Hence, also, the great value of balancing exercises for postural tone.

Recent work by Moody in California (*J.A.M.A.*, December 8,

1923), on the position of viscera in 600 healthy young adults, suggests that viscera may be low as a congenital anomaly, without the usual neurasthenic symptoms, and that position is independent of abdominal musculature.

To determine the strength of abdominal muscles, the subject lies on a table, and, keeping heels on the table, comes to a sitting position as many times as possible, without intermitting for rest. These subjects repeated this 50 to 80 times.

In physically assessing a person, posture is the first observation. To the educated eye, the figure is immediately balanced about its vertical axis. In good posture there is a proper balance, in poor posture irregularity shews at once.

In inspection for actual comparisons and reference, a background marked with horizontal and vertical lines is useful.

Some years ago, the writer judged children as they passed through a well-lighted square-headed doorway. Determine whether the head is well carried, spine straight, shoulders level, and shoulder blades flat. The normal position is in a vertical plane, with hips neither thrown back nor dropped forwards. The toes should be pointed straight forward, not outward.

A triple test of posture is described by Miss Bancroft (*Journ. Sci. Phys. Training*, Autumn, 1919). Three eliminating selections are made. Good candidates remain standing, the poor sit out.

First.—Profile attitude standing.

Second.—Those who are passed first, are then marched and postures watched. Any case with relapse into bad posture a tap on the shoulder eliminates.

Third.—The survivors are now lined up and viewed in profile. They are made to swing arms forward and up, palms facing at shoulder width. Those who lower forward the head, or make a forward movement of abdomen, are eliminated. The rest have passed the triple test.

This posture test is of great value. The profile view of the individual is extremely instructive to the pupil. Shadow outlines drawn in sunshine, on brown paper with chalk, are easily made and useful.

The Schematograph (*School and Society*, 1915. 642) is used among elder girls in America. A reflecting camera throws a picture of the sitter on a piece of tracing paper so that the outline can readily be run round with indian ink to give the profile. Its accuracy varies with personal equation of the tracer. The lens of the camera is pushed through a black curtain, and some 15 ft. or more from this, on a stool a foot square, the patient stands, illuminated by a couple of 1000-watt tungsten lamps (much less light will do). There is a dark background to throw up the body well, and a small white screen can be used behind the head if necessary for dark hair.

Miss M. R. McKee, of University of Wisconsin, finds the profile thus obtained of extreme use, not only for demonstration to the patient, but also for following changes and improvement in posture.

Freshmen at Harvard are classified A, B, C, and D, according to photograms taken of their standing position. Silhouettes are taken in natural profile and back, and then in best profile position as placed by the instructor. A modified camera is used which costs about half a cent each exposure (*Am. Phys. Ed. Rev.*, 1924. 219).

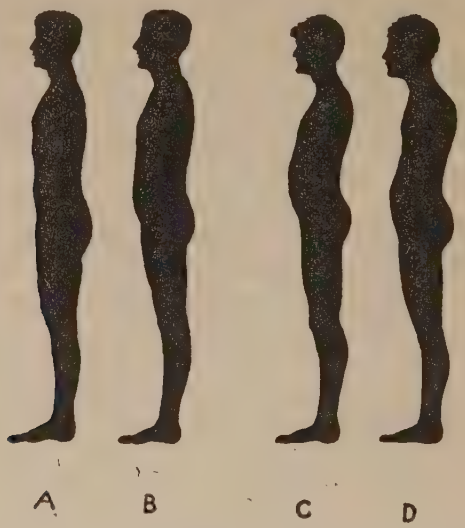


FIG. 17.—TYPICAL POSTURES OF HARVARD FRESHMEN.
A and B good, C and D bad.

THE RIGHT WAY.

(A) Excellent mechanical use of the body.
1. Head straight above chest, hips, and feet.
2. Chest up and forward.
3. Abdomen in or flat.
4. Back usual curves not exaggerated.

(B) Good mechanical use of the body (compare with A).
1. Head too far forward.
2. Chest not so well up or forward.
3. Abdomen very little change.
4. Back very little change.

THE WRONG WAY.

(C) Poor mechanical use of the body.
1. Head forward of chest.
2. Chest flat.
3. Abdomen relaxed and forward.
4. Back curves exaggerated.

(D) Very poor mechanical use of the body.
1. Head still further forward.
2. Chest still flatter and further back.
3. Abdomen completely relaxed and slouchy.
4. Back, all curves exaggerated to the extreme.

The improvement effected is shewn by percentages in different categories for four years (as recorded in 1923, Table 29).

Posture has to be considered as a whole, every muscle and joint has to be readjusted if a single one changes its position. Various

parts of the body in this respect cannot be treated separately. A round back means adjustments even in feet, and if one group of symptoms alone, whether back, head, shoulder or abdomen, is treated without respect to the rest, the result will almost certainly be unsatisfactory.

Satisfactory posture, which can be assessed at a glance, is the key to physical education of a scholar, and indeed in large measure to his total efficiency both mental and physical. A right attitude physically, that is, good posture, should be habitual and constant, and a lapse from it regarded as quite as serious as a lapse from a right attitude ethically. Good posture is as important, and to be upheld as constantly as good morals.

Table 29.

Class ..	A.	B.	C.	D.	Numbers.
1923	1·0	14·8	49·3	34·9	513
1924	2·4	17·2	51·4	20·0	599
1925	2·7	22·5	47·7	27·0	773
1926	2·6	20·8	49·9	26·6	758

Dynamic Effects of Exercise.—Almost the first response to muscular activity is the determination of blood to the muscles in action. Innumerable adjustments are rapidly made to supply the oxygen necessary to keep those in as normal condition as possible. It is not only the muscle in action, but the whole body that feels the stimulus. The chemical products of the muscle activity, chiefly lactic acid, locally produced and accumulating in quantity, become generalized in the blood stream. These products, including heat at first, are a stimulus to all the cell activities, but normally are rapidly removed. If the muscle action is massive and long continued they accumulate, producing toxic effects described as fatigue.

In all exercises for physiological benefit, massive but not long continued effects are wanted to obtain the stimulus without exhaustion. The removal of heat produced is referred to in connection with ventilation, but its removal is of prime importance and is effected by flushing the skin with blood, stimulating the sweat glands to perspiration, in evaporation of which much heat becomes latent, as it also does in a considerable part in the increased vapour excretion through respiration.

Rapid breathing acts, increasing the supply of venous blood to the heart. Physiological dilatation follows, and with each stroke mechanical efficiency in the heart work increases to keep up supply of nutrient material in the blood stream by increased

output of blood, and to help to remove waste products and heat from muscles in action. Escape of carbon dioxide through rapid respiration, also helps to maintain oxygen reserve which otherwise would soon be used up.

Pulse Rates and Exercise.—One of the writer's first school enquiries was, on the effect of exercise on the pulse in children. Very young children set to run at top speed round a small playground for about half a minute, in several cases collapsed and fell, but in a second or two ran on again, apparently getting a condition of heart failure from sudden dilatation, which almost at once recovered itself, the pulse rate soon coming back towards normal.

Three sets of older children, about 12 or 13 years of age, in a

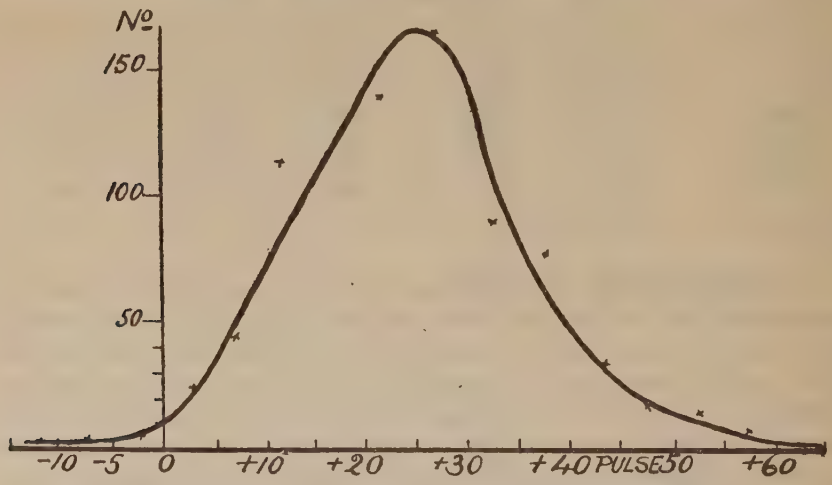


Fig. 18.—EFFECT OF RUNNING ON BOYS' PULSE RATES.

secondary school, ordinary boys, tug-o'-war team, and a set of pupil teacher girls who had no special exercise, tested by their fastest running down 62 steps and back again, each gave different results. The trained boys recovered their pulse rate in a couple of minutes; the others were four or five times as long, whilst for the girls, there was from twenty minutes to half an hour before they got back to the normal rate (*Practitioner*, 1902. 5).

Twenty years later, Foster, using 834 American school-boys aged 14 to 19, found the average pulse rate 95; then they were made to run in place for 15 seconds, when it averaged 120, and after three-quarters of a minute rest was about 96 (Fig. 18).

The acute dilatation of the heart shewn by some infants and rapidly recovered, is almost physiological. Power of the heart is much increased when it dilates slightly, indeed, within limits, its power is increased *pari passu* with its volume at beginning of systole.

This dilatation enables it to receive more venous blood with each beat, the venous inflow is increased chiefly by movements of the diaphragm and abdominal muscles, and the heart wall yields to this inflow. In sustained efforts, power of the heart depends largely on its form, and its power of response due to that form (Fig. 58).

The large squat heart can endure where the small vertical tubular heart fails. This is well demonstrated in a paper on the forms of the heart in Marathon racers (*Amer. Phy. Educ. Rev.*, 1911).

My colleague, Clive Riviere (*School Hygiene*, 1910. 144), examining boys on school journeys, was impressed with the variety and shape of the heart within physiological limits. He mapped it out by deep dullness, found on light percussion with a single finger, during quiet respiration. He took as the standard heart in boys, one whose left limit is a quarter inch within the nipple line, and the right limit not more than $1\frac{3}{4}$ in. to right of mid-sternum. He finds compensatory physiological dilatation from a few minutes' violent exercise.

Cardiac enlargement from muscular weakness, with increase in pulse rate, appears commoner in some schools, but rather due to ill nutrition, debility, and feebly septic conditions than over exercise. Physiological murmurs and variations in rate and rhythm after exercise are usually systolic and heard at the apex, mid-sternum, or base. If the heart is within normal limits as to size, and responds well to exercise, they may be neglected.

The effect of previous physical training on cardiac efficiency is enormous. Mumford discovered (*B.M.J.*, 1913. ii) how in the secondary school many are prevented reaching full strength because forbidden exercise without any reference to its amount.

During exertion, cardiac output may be increased up to ten times the normal, and strain be shewn by lowered blood pressure, which persists for a considerable time. The healthy heart which responds well to exercise is toned thereby, and afterwards is found by roentogram to be smaller. This is normal healthy reaction. The dilated heart can turn out more blood with each beat, the difficulty is to get it filled, and this is done by abdominal musculature in its effects on the great veins. When the dilated heart is unable to turn out a sufficiency the pulse rate has to be increased. This indicates that reserve power is being used up.

Clifford Allbutt notes that if, "As in a few cases which I see again and again in growing youths, dilatation of the heart occurs, leading to cyanosis, panting, confusion or vertigo, the oppression is generally sufficient of itself to stop the exercise in time."

For practical purposes physique as determined by efficiency is nervous capacity to maintain respiration and circulation normally.

Breathlessness is an early sign of cardiac inefficiency, and the test of efficiency is absence of undue breathlessness or distress of any kind. In testing general physical fitness, and effects of training, trained muscle is found to increase in power beyond its increase in size. There is a range of adjustment, securing the continued supply of oxygen necessary, by added efficiency in respiration and circulation. It is not general muscles that give out, the heart yields first. But the heart will hold on when the oxygen want is urgent.

Tests should not rely on performances, which may be aided by practice or knack. Indirect tests showing response to effort are best, although they are also affected by emotion. Schneider points out that judgment of a test is by what it measures, and that it should only be used for that. Efficiency must be judged by working load. There is a normal load which can be endured day in day out, without stress or failure. There is also a peak load, when every structure is working to the full and no reserve left; this can be endured for an hour or two, and with rest complete recovery comes in a normal time.

Oxygen intake rises rapidly to a maximum in about a minute and a half. In a healthy man it can be about 4 litres in a minute. The mechanisms which accumulate lactic acid in muscle, allow postponement of oxidation of this material to accumulate as an oxygen debt, which may amount to 15 litres of oxygen; beyond this complete fatigue from the products results. The maximum effort made in a given time can be expressed in litres of oxygen, for a litre is the equivalent of about 5 calories or 7 foot-tons. The maximum effort x per minute would be $\frac{x}{t}$, and is equal to $(4\ t + 15)$ litres of oxygen (A. V. Hill, *Lancet*, 1925. ii. 481).

Overload cannot be continually suffered, and if with rest there is not recovery to the original condition even after a night's sleep, this overload (Überbürdung) is the beginning of failure in physical or mental bankruptcy. A. V. Hill has described the fundamental principles in the Oliver Sharpey lectures for 1924.

With normal load the oxygen account balances and a reserve remains. With crest load it still balances, but there is no reserve. With overload scanty oxygen capital is being used up, and the balance is overdrawn. It is the condition of staleness.

Fitness depends on condition of blood, respiration, and nervous system. The first pair are too complicated to observe for school purposes except in the roughest way. Nervous adjustments which first fail from oxygen want, shew in loss of the automatic controls. The regulation of the heart loses, and the pulse runs off. The breathing centre is accelerated for want of control, vaso-motor centres let down the blood pressure, and in chronic cases nervous

TABLE 30.

STANDARDIZED TEST EXERCISES. (DR. MAY WILSON.)

Test Exercises.	Age in Years for Standard Weight and Height.	Simple or Mild.			Normal Range.					
					Average.			Severe or Strenuous.		
		Number of Dumb-bells.	Weight, Lb.	Swings, Times.	Number of Dumb-bells.	Weight, Lb.	Swings, Times.	Number of Dumb-bells.	Weight, Lb.	Swings, Times.
Dumb-bell Test .. .. Swinging two iron dumb-bells from the floor to full stretch of arms over-head and back again between the legs at a constant rate of two seconds for each swing	6–8	2	3	10	2	3	20	2	3	30
		2	4	10	2	4	20	2	4	30
	8–12	2	4	10	2	4	20	2	4	30
		2	5	10	2	5	20	2	5	30
	12–15	2	5	10	2	5	20	2	5	30
		2	7	10	2	7	20	2	7	30
		2	10	10	2	10	20	2	20	30
	Age, Years.	Number of Flights.	Rise, Feet.	Time, Seconds.	Number of Flights.	Rise, Feet.	Time, Seconds.	Number of Flights.	Rise, Feet.	Time, Seconds.
Staircase Test .. .. Stairs taken at a steady climb without rest	6–14	2	15	40	4	30	40	4	30	20

REACTION OF AVERAGE NORMAL CHILDREN FOLLOWING TEST EXERCISES.

	To the Mild Test Exercise.	To the Average Test Exercise.	To the Severe Test Exercise.
Colour of face (flushed)	..	+	++
Degree of dyspnœa	..	+	++
Degree of fatigue	..	..	+
Rise of systolic blood pressure	10–15 mm.	20–30 mm.	30–40 mm.
Type of systolic curve	Normal	Normal	Normal

centres may suffer permanently, producing the so-called "effort syndrome," of tachycardia and breathlessness, which occurred so frequently during the War.

Exercise Tolerance.—Dr. May Wilson (*Am. Journ. Dis. of Children*, September 1920) attempted to standardize normal reaction of the heart to exercise in children. The child is exercised by swinging dumb-bells, two seconds to each swing, until its maximum effort is reached as shewn by breathlessness, flushed face, perspiration, and fatigue. The result of her work is set out in the table 30. With maximal exercise, pulse rate increased from 5 to 100 beats a minute. In 57 per cent. normal was regained in two minutes ; in 28 per cent. it dropped below normal after two minutes. In cases of maximal effort it was noted normal after two minutes, whilst oxygen want in dyspnœa and fatigue still persisted. She concluded that time taken to return to normal did not give much clue to exercise tolerance.

Variations in Blood Pressure through Exercise.—Effect on blood pressure when moderate exercise is without dyspnœa, is a steep rise in pressure reaching a maximum in 20 to 40 seconds, and quickly falling to the previous level in two minutes. With the severest tests there is an increased rise with a prolonged period of rising up to 50 to 70 seconds, and slow fall to original rate in three to five minutes. The severest test was followed by the same curve day after day, but effect of training shewed in the heavy test being performed without delayed rise, and without dyspnœa.

It is doubtful how far these conditions apply to diseased hearts. Probst failed to find such changes in a hundred organically affected cases which he tested. He thinks delayed return to normal of the pulse rate is more valuable as a test of efficiency than delay in the rise of blood pressure which accompanies a heavy task (*J.A.M.A.*, 1924. i. 2100). Probably the real basis is the rate of oxygen intake not being quite equal to production of fatigue products, leaving a constantly increasing "oxygen debt." A. V. Hill has shewn the effect of this in the diminution of rate of work being proportioned to its duration in established records for running.

There are other conditions making for inefficiency ; for instance, lessened control by nervous adjustments shewn in the condition of relaxation or want of tone of the abdominal blood vessels, also shewn temporarily during digestion or in fatigued conditions, where attitude makes a considerable difference in blood pressure. The two factors may be combined, as in elderly persons who tend to sleep in their chair after meals, from the determination of blood to the viscera not being sufficiently controlled and leaving the brain relatively anæmic.

The person who faints from fear or exhaustion does so from

loss of nervous control over abdominal vessels which fill, leaving the brain unsupplied. Treatment is to lay them down flat at once, when blood is redistributed and the brain gets its share.

Ward Crampton has endeavoured to standardize efficiency by capacity to resist alterations produced by gravity. The Ward Crampton index, or blood ptosis test, depends on alteration in blood pressure, taken first, resting horizontally, then standing up, the pressure in the brachial artery ought to be raised about 10 mm. In a debilitated subject it may fall 10 mm. within limits of health. In health the pulse rate will not increase more than a beat or two, but in the weakly it may increase by more than fifty. This varies with blood pressure change and sometimes replaces it.

One millimetre change of pressure roughly corresponds to two

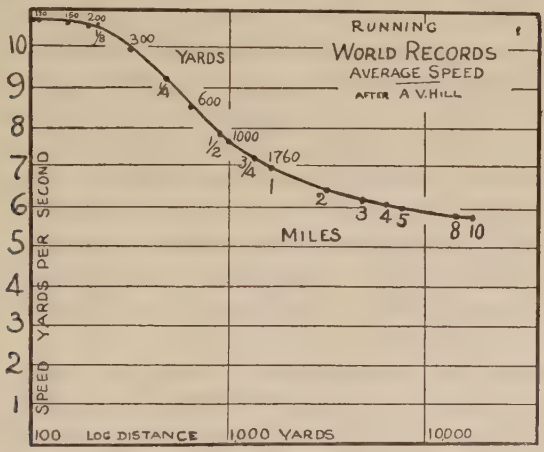


FIG. 19.—AVERAGE SPEED OVER VARYING DISTANCES. LOGGRID.

beats a minute in pulse rate. Allowing for these two factors he makes up a score for efficiency varying from 100 to zero, the last being a person unable to maintain the upright position steadily.

The Schneider test (*J.A.M.A.*, May 29, 1920) is being much used in America on adults, but would require re-rating for children.

Barringer studied functional capacity by estimating the work done in swinging dumb-bells, and tracing variation of blood pressure (*Arch. Int. Med.*, December 1917).

Sargent (*Am. Phys. Ed. Rev.*, April 1921) attempted to measure efficiency in a similar way by finding the height through which a person could jump raising his own weight. A horizontal cardboard disc above the head had just to be touched. The individual bends forward, flexes the joints and springs up. The greatest height at which the disc can be touched, less the height of the individual, gives the jump.

The Sargent Index $= \frac{\text{Weight} \times \text{Jump}}{\text{Height}}$. Attempts to correlate this with the Schneider index shew that they do not measure the same qualities. Later Sargent (*Am. Phys. Ed. Rev.*, February 1924) shewed that for students height of jump is independent of height and weight, and a measure of efficiency. Under 17 years of age there is a small positive correlation with age. The test is not a test of strength alone, but also of speed, co-ordination and will power. It has the advantage that it cannot be beaten by any tricks of execution, and is applicable to a wide age range in both sexes.

Blood pressure in children has not had much study. Children from 2 to 5 years give systolic pressures of 75 to 90 mm., between 8 and 9 years they run from 85 to 100 mm., and gradually increase with age (p. 267).

For young men of the Air Force, Flack considers that where systolic and diastolic pressures are persistently high and the pulse pressure exceeds 50 mm. (for example, Syst. = 160, Diastolic = 104, Pulse pressure = 56), a "nervous temperament" is indicated, and one not likely to stand great physical or mental strain.

Physical Types.—Reactions to muscular work by increased respiration and by increased blood supply, are under control of the nervous system. These adjustments belong to lower nervous levels and are involuntary. Involuntary or subconscious nervous action being as wonderful as any voluntary actions.

These levels are only indirectly educated, that is, perfected in adjustment and quickness of response by being exercised, and without proper physiological functioning their full development fails.

The city dweller falls short of his possibilities mainly from want of physical exercise. His miserable muscles and inadequate capacity of physical response again set up a feeling of inferiority which reacts on his mentality, and makes him attempt to preserve self-esteem and self-respect by becoming a slave to conventions and snobbery.

Good physical habits are economical. They are of the nature of conditioned reflexes, and whilst many details of exercise and gymnasium work are trivialities, there is much that is useful in practising details of movement, and methods of advantageous action. These belong mainly to gymnastic technique and are doubtfully of any general advantage in elementary schools. Infants want purely physiological, nutritive, or vegetative effect in promoting growth and nutrition, which is the basis of good physique.

Active short exercises in which at intervals the child exerts its very utmost effort, the rough and tumble of violent play, is far away the best method of functional activity of nerve and muscle

at elementary school ages. It cannot be trained in precise movements except at serious nervous cost.

For physiological exercise every child required considerable intervals, at least three half-hours in an open playground, with many others of his own age and strength, every day of his elementary school life. The time table of elementary schools should have three hours, or 180 minutes weekly, scheduled as physical exercise. When growth, food, and exercise are all considered, there is yet another element. Certain small ductless glands, phylogenetically related to the nervous system, appear to influence physique and growth by their products, so called hormones, in the blood. Just as infinitely small quantities of vitamins in food make the difference between robust health and struggling lack of vitality, so small quantities of secretion from various glands, such as thyroid, suprarenals, parathyroid, pituitary, and other structures, affect physique in a way which cannot yet be set out. Their functional capacities are largely matters of heredity. With the thyroid glands it is an iodine deficiency which is the main cause of defective action. The result of many of these factors, although their interplay is as yet unknown, is that types of physique occur. Some races are short, others tall, some broad and fat, and so on.

Professor R. Tait McKenzie's thoracic index has been referred to, and the measurements of many Greek statues portraying physical efficiency shew this index very different from the American athletes.

The idealized forms of Art conventionalized much, so that a Greek statue has an aspect of firmness and solidity about its flesh forms which apparently defy the sagging of gravity, and at the same time eliminate the grossness and realism of modernity.

The Venus of Milo measures 64 in. in height with a $21\frac{1}{2}$-in. head, $12\frac{3}{4}$-in. neck, 35-in. chest, $25\frac{1}{2}$-in. waist, and 38 in. round the hips ; proportions very different from the flaccid forms portrayed with flattened chests, rounded backs, lordotic spines, and enteroptosis in the present fashion advertisements in the daily press.

Attempts have been made to classify general types. These types, however, are not sharply marked except in extreme forms. The epigastric arch, for instance, varies about a mean. Measurements of young adult men at Rochester Y.M.C.A. (*Am. Phys. Ed. Rev.*, 1924. 124) gave the smallest angle 48 degrees, the largest 110 degrees (Table 31).

De Giovanni of Padua (1880), assuming that external structure of body reflects inner constitution, attempted to classify individuals. His work was developed by Professor Fabio Frassetto, whose physical classification of children is set out on page 292 of Bulletin No. 60, *Standard of Child Welfare* (U.S.A.—Dept. of Labour, 1919).

He classifies :

1. Heavy physique, brevilinear or macrosplanchnia as the sedentary torpid type.
2. Slender, longilinear type, with microsplanchnia as active and excitable.
3. Normal individuals (normosplanchnia).

Different nervous growth of sympathetic or neuromuscular systems may account for these types. Each may be subdivided according to size of the head (micro, macro, or normocephalous) and limbs (micro, macro, or normomelic). With this classification one does not get much beyond general morphology.

Sigaud grouped children as digestive, muscular, respiratory, and cerebral types, and Coerper (*Zeit. f. Kinder.*, 1922) argues that standards of nutrition can only be compared within these groups. The full development of the type is, however, only to be expected after puberty.

This classification has been considerably elaborated in *Morpho-*

Table 31 (Epigastric Arch).

Arch ..	Below 50°.	50°–60°.	60°–70°.	70°–80°.	80°–90°.	90°–100°.	Above 100°.
Number seen ..	1	3	34	63	47	7	6
Percentage ..	0·6	1·5	20·9	38·9	29·0	4·3	3·0

logie Medicale of Chaillou and MacAuliffe, who in addition take the face in segments, a line drawn through the upper edge of the orbit marking upper cerebral from middle respiratory section and a horizontal line through the lower edge of the alæ nasi separates this from the lower digestive section. Each of these sections of face is predominant with the respective type.

The respiratory types have a face of lozenge type (Bertillon), long noses and necks and depression of the temporal fossæ.

The thorax, long chested is greatest part of the trunk, xiphoid angle acute and space between the false ribs and ilium short.

The digestive type may differentiate in the first year of life. It is more accentuated in trunk than in face which is *face en pyramide*. There is a large, short thorax, the false ribs being far from the iliac crests. The flanks almost always allow the kidneys to be felt. The eyes are usually small. The trunk may be small, sternal angle 90 degrees ; they fatten or emaciate easily. Kretschmer uses the term "pyknic" for the heavily set type.

The muscular type has the three sections of the face about equal in size and height.

The *face rectangulaire* of Bertillon.—Fine limbs corresponding to classical ideal, some have long necks and small heads, but usually there is a good head on a good neck. The xiphoid angle is about 80 degrees, and false ribs are a moderate distance from iliac crests. The type does not markedly differentiate till puberty ; those who do so early, rarely grow up.

The cerebral type has a small body with a large head and a small, round face with good, large eyes. It is a frequent type in persons of small size. There is a short neck with sloping shoulders and poor trunk and limbs.

"Development Croissance."—Dr. Leo MacAuliffe regards these types as environmental. Living matter is plastic in this regard, and environment aids the production of the type. He states the digestive type occurs where soil is fertile, food fresh and varied. The respiratory type prevails among nomad tribes ; muscular in tillers of soil, and cerebral chiefly in urban brain workers. A large number do not come under these types, they constitute a round type, but all kinds of varieties exist as result of environmental differentiation.

A splendid paper on mechanistic conceptions of disease (Goldthwait, *Bost. M. & S.J.*, 1915. 881) analyses a number of descriptions by various authors into two types.

A. The thin, carnivorous type, with short intestines. They are the congenital visceroptotic type, with narrow, slender backs, of little use industrially, delicately textured, large headed, with adenoid excess, having long ribs, the tenth ribs often free. The pelvis is much tilted forward and costal arch small.

B. The heavy, herbivorous type, with long intestines, broad backed, pelvis straight. Coarse textured, with much fat, short ribs, the tenth attached, and costal arch 90 degrees.

In Art the slender type is seen in works of Botticelli, Fra Angelico, and Puis de Chavannes. The heavy type predominates in works of Rubens and the German Masters.

In the normal type the abdominal cavity is pear-shaped with the thickest part upwards, but in the visceroptotic this is reversed, the upper part of the abdominal cavity being narrow compared with the lower.

The heavy typed spine resists displacement of intestines for years, and the sternum is carried high ; with the other type the spine is slender, becomes arched over a flat chest, and intestines sink down. The slender type is said to be most prolific. If their expectation of life was as good as that of other types, there should be more of them ; this is very doubtful.

A consideration of these types has importance in regard to

deformities, prognosis of treatment being worst in the slender type.

Stiller's Sign.—About the beginning of this century, Stiller of Budapest described his *stigma costale*, a floating tenth rib either unattached to the sternum or only by the thinnest strand of cartilage, so that the end can be moved freely. This condition he put down as accompaniment of visceroptosis. He described a congenital asthenia associated with this type, and it is the erethic, gracile, long thoraxed, narrow-backed type, prone to nervous troubles and tubercle.

Moritz, in adults, found visceroptosis varied with freedom of the end of the tenth rib.

Leipoldt examined 500 Bermondsey children and found Stiller's sign in 10·8 per cent. boys and 16·4 per cent. girls, all of whom were subnormal in nutrition.

Stiller (*Wien Med. Woch.*, 1900–9) found the costal sign in 17·6 per cent. of 3198 children, of these only 21 per cent. were considered normal. He says prognosis in bad nourishment is much worse if this sign is present. There is generally diminished pulmonary capacity, and with any family history of tubercle the child should be watched as a pre-tubercular case.

Congenital Asthenia.—Recently, Wetzel (*Munch. Med. Woch.*, September 1922) describes infants of elegant slimness, with long, sloping ribs and Stiller's sign. He considers them as early cases of congenital asthenia. It is this long-limbed, slender type which in modern civilizations is generally held to typify "good breeding". It is doubtful, however, whether this type is best. The tendency to verbalism in education and as a means of success in life of highly civilized states may make for present success of the type, but it has not the vitality that may be expected to survive. It is a long body rather than long limbs that makes a child a good animal.

The tendency to visceroptosis often reacts through lack of physique, want of exercise, defective circulation and nutrition, to produce neurasthenic conditions, and a want of tone, whence originates a hopeless vicious circle of ill health in middle life.

Other types which should be known, are almost pathological. Status lymphaticus one associates with sudden deaths under anæsthetics. It is very indefinite, but is recognized by the persistent thymus. There is general hypoplasia of the vascular system, with a delicate, clear, pale skin. The feminine type of body and hair prevails, with the hips as wide as the chest. They are said to be prone to suicide and crime, but as about 10 per cent. of the population present the anatomical characteristics, this is doubtful. In sudden deaths of infants with capillary bronchitis or pneumonia the condition is often present.

This thyro-lymphatic hyperplasia, if detected, as it rarely is, has to be noted, as it seems associated with diminished prospects of life.

Infantilism embraces a group of various complicated origins in which growth may be retarded by many years. Mere dwarfing as a physiological variation of growth might be included, but often there has been retardation from toxic action on some endocrine glands. The commonest are children who have suffered at an early age from tuberculosis of abdominal glands, and recovered to grow up dwarfed in body and limbs, but otherwise normal.

Idiopathic Infantilism, first described by Lorain, is supposedly due to vascular hypoplasia, associated possibly with pituitary deficiency. The individual is small and childish mentally, although otherwise of normal proportions. Other varieties of dyspituitarism are seen in increased growth, the adipose genital dystrophy, or the other form, acromegaly, seen in later life.

The pathologic cases due to early cachectic conditions like abdominal tuberculosis, Pott's disease, some heart conditions and possibly congenital syphilis, are retarded in the growing period and never made up. Another set due to glandular insufficiencies of thyroid, pancreas, or intestinal tract usually have childish disposition and development. There are children who develop prematurely in sexual life, a condition associated with tumour about the kidney. The typical fat boys, mentally dull and lethargic, sexually undeveloped, are associated with pituitary insufficiency, dystrophia adiposogenitalis, and sometimes recovered from, with further growth. The fat boy of Peckham, for whom no desk was big enough in the early years of this century, grew into a shapely youth, as Nature made fresh adjustments in the glandular economy.

The scaphoid shoulder blade, where the median edge of the scapula, which is normally convex, is actually concave, and the inferior angle below the middle point of the spine, is a congenital deformity of unknown cause. As it is common in early life and rare later, Kollert (*Wien Klin. Woch.*, 1912, 2002) suggests that it prognosticates a short life, tuberculosis of an acute type being frequent.

Thyroidal Variation.—The thyroid gland, which is largely a regulator of metabolism, may have almost normal variations affecting the type of individual. P. B. Mumford describes the skin reactions which give useful indications. The vasomotor control of the peripheral circulation acting as a delicate test. Stroking a boy's back with a round-tipped bobbin under about 2 lb. pressure the normal reaction is a simple red tache with paler edges, the red and white tache. This may be exaggerated. An early red spreading tache appears as a deep erythema, and within a minute or two a whitish raised centre may form a wheal. This is probably an erethic, fine-skinned type of boy, lively and active, and easily exhausting himself. He has high thyroid activity and increased metabolism. Corporal punishment in such a case might easily appear excessive.

With decreased thyroidal activity the individual seems dull and backward, wanting in power of reaction so that he is easily chilled. The skin reaction is likely to be of poor colour, slow onset, and slight duration ; the early cyanosis reaction. There is a tendency to dry, coarse skin in this type.

Thyroidal disturbance.—The thyroid gland responds to many toxic stimuli.

Leipoldt examined cases of enlarged thyroid in London school children, and put them nearly all down to focal sepsis, of which dental sepsis was the most frequent, as shewn by improvement on treatment. His worst case was probably a frustrate case of Graves's disease, as the mother, aunt, brother, and sister all had this disorder. In the ordinary slight goitrous change found in school children, about 3 to 5 per cent shew it, but this includes the pubertal excess ; many other cases occur in the family. A spot map shewed the cases most prevalent in better-class districts of Leicester.

McCarrison, who has associated one form with infection in drinking water, states that it is mostly seen in Indian schools in Autumn and Spring after the rains, and relieved it by administering thymol as an intestinal disinfectant.

In the Great Lake Districts of America it is prevalent. The women students at Wellesley College shewed 16 per cent. of 2333 examined, and 10 per cent. had also fine tremors.

The slight hyperthyroidism is relieved by administration of soluble forms of iodine. Iodine is found scanty in the soil where this thyroidal disturbance is common.

Kimball and Marine at Akron, Ohio, completely abolished the symptom in school children by administration of very small doses of iodide for a week or two at intervals of some months. Good results are also being obtained in Switzerland.

Its importance in this country is little, except as an indicator of slight chronic sepsis. Elsewhere its presence should suggest the advisability of adding traces of iodine to the drinking water, preferably as sodium iodide. The iodine occurs in a substance, thyroxin, isolated by Kimball in the Mayo Laboratory, and since prepared synthetically. This substance seems to be one of the dynamic stimulators of bodily energy.

Thyroid and Heart at Puberty.—At puberty there are conditions so common as to be almost worthy of consideration as normal. The girl during development often shews temporary hyperthyroidism at any age between 13 and 17 years. This has always to be suspected as possibly one of the *formes frustrées* of Graves's disease. The typical case may vary from a girl with a full thyroid and rapid pulse not otherwise abnormal, to a case, which with intermitting feverishness, may cause one to suspect incipient tuberculosis.

Easily produced fatigue, often a fine rapid tremor of the

extended fingers, and a certain emotional strain in behaviour may be added on. In a few cases, but very rarely, slight exophthalmos, lagging of the upper lid in downward movement of the eyes (Von Graefe's symptom), or perhaps more commonly the staring expression from retraction of the upper lid on fixation of an object by the eyes (Stellwag), may be noticed. As a rule they recover with time, but rest and avoidance of excitement or strenuous work is an aid. The writer has always rejected such cases with eye symptoms as candidates for the teaching profession.

This thyroidal condition is rare in boys, and seems replaced by a tendency to rapid pulse, and symptoms suggestive of the effort syndrome. The neurotic heart may be associated at this age with the heart for a short time being relatively smaller than at any other time. Here again, whilst rest and avoidance of fatigue are helpful, common sense will allow the boy to do anything he likes so long as he does not get breathless. He must not be made hypochondriacal or have invalidism suggested. Where there is a tendency to pooling of the blood in the great abdominal vessels from efforts of exercise, this is often due to the weak, flabby abdominal muscles. To compensate failure in circulation the heart rate is increased rapidly. The condition is sometimes taken for myocarditis and rest enjoined, when carefully regulated exercise is needed.

The rate of growth of the heart (p. 281) sometimes produces temporary troubles.

Physical Inefficiency.—When the writer began to investigate conditions of elementary school children in the last decade of the past century, he was much surprised to find less serious, but more slight disease or disorder of every kind than would have been expected from experience gained among hospital out-patients. The deviations which shew up in adult life were just beginning, and as yet not obtrusive. Arkle, and also Crowley (*School Govnt. Chronicle*, January 12, 1907), were among school doctors making early comparisons shewing widespread but slight defects.

The Director-General, in his Report to the War Office (Cd. 1501, April 2, 1903), states that "A large proportion of the population live in towns, and this has been estimated at 77 per cent., or 25,000,000. Of this town population about 25 per cent. (probably at least 6,000,000) appear from trustworthy investigations to be not only poor, but living in actual poverty, so as to be unable to rear their children under conditions favourable to health and physical fitness. The bulk of the men who seek enlistment belong to this section of the population, and a very large proportion (but probably not quite three out of five, as stated by General Maurice) of the men who wish to join the Army prove physically unfit for military service."

This Report, of course, did not apply to the whole population; that was to be tested after 1914.

A year before the War, in 1913, only 55 per cent. of the Prussian recruits were capable of bearing arms (Wehrfahigkeit), and of the better educated claiming exemption after one year's service, only 65 per cent. This was in a land where the whole purpose of the educational system had aimed at supplying the Kaiser's demand, "I must have men" (*Ich brauche Männer*).

In Britain, the survey of nearly 2,500,000 men between 18 and 41 years of age, "under the icy blast of War which sweeps before it everything except hard facts," gave only 36 per cent. fully normal, whilst 10 per cent. were unfit for any kind of military service. They were classified in four groups: the proportions of which Keith calculated out for a normally healthy community.

TABLE 32.

KEITH'S CLASSIFICATION.

	Good.	Fair.	Poor.	Bad.
Percentages calculated ..	70	20	7·5	2·5
Actual result	36	22·5	31·3	10·2
Actual numbers	871,769	546,276	756,859	250,280

Results in America were equally unsatisfactory. In Massachusetts, 40 per cent. of men called up in the first draft were rejected. Tait McKenzie, who came across to work with the British Army, inspected camps and reported on their wonderful success, but the training shewed what was missed. "It is on the playground that the child really lives. In the school he only prepares to live, and that is why a director trained and paid for this work is essential if playgrounds are to become real laboratories for cultivating both body and character."

Testimony is equally strong that freshmen admitted to American Universities have considerable proportions defective physically, so that no level of society is at present fully educated in this respect.

Tait McKenzie found most students, on entering college, have to begin the simplest movements and easiest muscular tasks. Many men cannot jump over a cord two feet from the ground, or lift their weight by their arms. They do not know how to stand properly erect, or to answer promptly and correctly a word of command. They should begin with class gymnastics, marching formations, drills and simple feats to teach control and agility. Athletic games have advantage of giving a moral or ethical training, and so have

an influence in moulding character, that would be hard to over-estimate.

Life in a state of Nature provided development of function in brain and muscles necessary for health and efficiency. The non-effective died, whether by starvation, drowning, or weapons of their adversary, they were lopped off comparatively early. To-day they are preserved and pass on their defective strains, so that increasingly large proportions of the population exist who are physically and mentally ineffective, and yet are shielded from the full forces of Nature's living experience. Teaching is, therefore, more wanted to compensate defects. Indeed, physical exercise is as necessary as fresh milk for the child's development, and both are urgently wanted by the majority of British children.

Necessity for Interesting Exercises.—Exercises in games have played a great part all through English history and are ingrained in national habits, but it is only the well-to-do who have had full benefit for many generations. Hours of abundant free play are practically reserved for Public School boys. The majority of ordinary English boys have insufficient opportunity, and their play-hours are trivial compared with what is required.

Ancient Greece had social centres in gymnasia, where not only muscular exercises were taught and practised by young and old, but apparently discussions and lectures on all kinds of interesting topics took place. They were for the few, but they present an example of what we may hope our schools will be ultimately for the many. Social centres might be built out of them, running through life with their pervading influence and effects. The Greece of philosophers, artists, and athletes was as little representative of masses living in Greece, and yet as impossible without them, as the life of the few English Public School boys is to the life of an average child to-day.

Time and means have yet to be found for exercise, permeating whole years of development and continuing through adult life. Playground and playfield for a large portion of his day should be the right of every child, and in this respect our system of elementary education requires most drastic pruning of academic and literary subjects, its level of teaching being beyond the capacity of the majority of pupils, and its starvation of exercise a cruelty and deprivation to childhood. Out-of-school work for payment is a crime against childhood in this respect which our State is slowly making impossible.

The late Dr. Sargent of Harvard has pointed out how all mental training required and special knowledge desired could be attained in half the time if more attention were given to physical education and bodily training. It is not more knowledge that is in demand at present, but more character. Boys are trained and educated

not so much by what they read as by what they do. Conduct is developed through physical activities, will is strengthened and character formed. The division of labour and economic conditions have deprived the boy of to-day of activities that developed his ancestors. The only lines of action left open to our youth are play, sports, games, general athletics, and gymnastics. These have come down from a remote past, freighted with ancestral experiences of greatest value; they are powerful agents in moulding character for good or evil. They should be incorporated with texture and fibre of our educational system and become an integral part of school and college curriculum.

Usual school gymnastic exercises are of scanty physiological value for the time taken, and are of deadly dullness. Lack of interest deprives them of much collateral value. Even explanations of their purpose does not give interest.

There is little in School Hygiene which does not come within scope of physical exercising of neuro-muscular structures, to develop growth and efficiency, and contribute to general health of the rest of the body. Michael Foster used to say the body mainly consisted of the tissues of digestion to provide fuel for the neuro-muscular engines, and the tissues of excretion to remove the waste of their action. Physical education, by utilizing all the bodily structures, is thus a means of general education; but it is a means, not an end.

Exercises are not performed merely to make a set of men goose-step with regularity of clockwork. They are done to develop red blood, good lungs and a sound heart, and with these control and self-confidence. To give readiness and alertness, and by means of games and sports to bring out the herd instinct in a spirit of sportsmanship and fair play.

Proper exercises will result in pupils who can make an effort when it is required, and face success or failure with equable poise, a smiling face and undisturbed confidence. It is the development not only of physical efficiency, but also of accompanying morale and character which is the educational aim.

This control of emotion is the flower of English Public School education, the tone which it gives to life.

The Public School boy, as a rule, carries off in the way of book knowledge but scanty learning of value in a highly mechanical civilization, but he gains in outlook and interest in his surroundings having a steadying and controlling influence throughout life.

The real test of any physical education is how it persists after and influences later days. Exercise is wanted at every stage, from birth to maturity.

Hughlings Jackson worked out the relations of the various parts of the nervous system. The coarser, more central movements of large muscles are those which were earliest acquired in the race and

are earliest developed in the individual. Some are present at birth, they are fundamental; others develop later and are more specialized, they belong to the middle level of Jackson, have to be gradually acquired, but easily become habitual.

Others represent most recently developed combinations and are late in acquirement—for instance, the pronunciation of certain complicated consonantal sounds are normally not acquired till the middle of school life, and indeed by some never acquired at all; these are almost higher level.

Some fine finger movements, again, are late attainments only got by definitely practising for the specific purpose; they are beyond the infant age.

Exercises must be adapted to the stage of development of the child. The crawling infant is a quadruped, and exercises itself till it can gradually stand, first in a monkey-like way, then it balances till it can freely walk in human attitude. For each kind of movement there is an optimum stage of development, for educational effects. Before this stage exercise will be fatiguing and improperly performed, leading possibly to want of development of some structures which should by then have been brought into action. If the optimum period is missed, full developmental effect of the exercise may never be obtained. Running activities, for instance, reach their maximum about ten years of age.

When by exercise any set of movements has been learned, the exercise may have physiological effects in indirectly promoting growth and nutrition, but it no longer has educational effect.

There is, indeed, a good deal of work in the schools even in other ways than physical exercise, which is thus waste of time. Apart from educational effect, the nutritive and physiological result is always valuable to the town dweller. Dr. Webber, when in his ninety-seventh year, wrote a letter to the *British Medical Journal* advocating brisk walking, to fifty miles a week, as a valuable means of maintaining a generally healthy old age.

Training for Sports.—Training in not to be thought of as in any way educational. The physiological reserves of various powers can be focused, as it were, and brought into regular use temporarily by practice. This is the purpose of training. What is exactly accomplished is not known, fatigue is not so readily felt, and for a short time the trained persons can use themselves more fully, where the untrained would be knocked out by exhaustion.

The trained man uses up oxygen in his blood more completely, and thus saves heart effort. The heart also empties itself more completely at each beat. Its muscle is in good condition and does not dilate so readily. With the same effort output of the trained heart is said to be less per minute than with untrained. The trained man, however, has no further reserve powers, and may have sacrificed

some. He seems to have diminished immunity to infections. The ordinary skin cocci, usually of little account, easily set up trouble ; and often the trained man is affected by boils, which are recurrent. If he gets influenza or pneumonia he is in great risk, compared with the average untrained person.

Training is not a condition to be looked on as desirable from a health point of view. A child seems unable to be trained in this way. Its reserves are perhaps fully employed in growth. Only after growth at puberty has slowed down does training come into play.

There is now wanted, for children from earliest ages up to puberty, a neuro-muscular scale on similar lines to the Binet Simon scale for intellectual levels.

As a first approximation it might be developed out of graded tests. This is done by walking under increasingly difficult conditions as mentioned below. The young child has to be taught the great fundamental movements necessary for progression. It acquires them more or less imperfectly by Nature, but should be taught to walk economically. It has to be taught posture or poise, this last is generally neglected till a stage when much has first to be unlearned.

Subconscious Education in Posture.—Luther Gulick used to say that the way to assure good posture in daily life was to "hold yourself so that you feel the collar stud at the back of your neck, and look at everyone you meet as if they owed you a dollar."

From the first day a child comes into school it should be taught balance movements. They are the foundation of upright attitude, which is one great human attribute.

The Committee of the American Physical Education Association (*Rev.*, 1924. 579) points out how much all the skill of big muscle movements depends on balance. This again requires for its adjustment aid of vision, and different stimuli from the semi-circular canals of the labyrinth. Without them movements are difficult. The Blind are handicapped until specially trained in walking. The Deaf all complain of uncertainty in dark. A deaf person will hesitate at a plank or a stair in the night which would cause no fear in the day. Blindfold a person and set him to stand on one foot or to hop. The third aid comes from the kinæsthetic sense.

John I. Hunter has taught us how intricate is the mechanism of posture adjustment from the muscles, and undoubtedly much can be done here in training. The writer found that want of balance of his own eye muscles (hyperphoria) prevented him accomplishing good balance—in skating, for instance—and caused feelings of insecurity on mountains, which in some amounts to giddiness. In the child below school age and in school, posture and balance outweigh all other considerations ; indeed, all exercises in school, if properly regarded, are merely subsidiary aids to producing these results,

which should be obtained more simply and interestingly by direct balancing.

In the school child these movements can be graduated from walking along a six-inch plank flat on the level, then on its edge, and on slope by an increasing series of difficulties, with or without a bean bag, ring, or plate balanced on the head, till walking on a sloping rope is attained.

There is no question about this primitive and fundamental exercise having not only an educational but a sporting element in it. It has the joy all through of advancing accomplishment towards a perfection scarcely to be reached, just as intense and perhaps more so than golf. The task involves ultimately every set of muscles, and yet is the simplest and most neglected of exercises.

Table 33.

Elementary School boys under 13.	All other Elementary School boys.	High School boys.
60 yards dash in 8⅘ sec.	60 yards dash in 8 sec. indoors	—
	100 yards in 14 sec. outdoors	220 yards in 28 sec.
Pull up (chin on bar) 4 times	Pull up 6 times	Pull up 9 times
Standing broad jump 5 ft. 9 in.	Standing broad jump 6 ft. 6 in.	Running high jump 4 ft. 4 in.

Each week can see something accomplished and yet leave much to be attained.

Dancing and skating are varieties of balance movements, but allow greater latitude for imperfect performance. Balance movements require fully developing into a graduated system, as physiologically and educationally they are of great importance for health and good training.

Standards of physical efficiency need determining for various ages (*School Hygiene*, 1920. 1).

The Public Schools Athletic League of New York initiated about 1910 an Athletic Badge Competition, for the qualifying events of which boys were grouped of a certain age reckoned on the first day of the school term (Table 33).

Chinning is defined in that the boy is to extend himself to his full length before and after each pull up, and is obliged to raise his body to such a height as to bring his chin above the bar.

Class Athletics.—Whole classes compete for the above awards and the best average wins. The boys get much interested, and work together out of school to perfect themselves. The best boys coach others. This development of the best boys athletically helping others, has resulted in welding of the classes together in a way that

is socially desirable. In ordinary forms of athletics it is not the custom for boys to help each other, inasmuch as each depends for his victory not only on his own strength, speed, and skill, but also on the lack of these qualities in his competitors. In this form of athletics it is, however, the average of the class that has to be raised.

Competitions for New York girls have also been arranged, with dancing and games, but they offer much scope for improvement.

With her lower centre of gravity, balancing exercises will be better performed by the feminine type of girl, but the heavy-shouldered masculine type will excel at the usual strenuous competitive tasks.

Efficiency tests on similar lines are being tried in Sheffield and London with satisfactory results in interest evoked and the actual results obtained.

For school exercises, proper clothing is recommended. The boys as free as possible, and the ordinary " gym " costume should be the rule for girls of whatever age. It adds grace to almost any young girl, and is vastly better than the ungainly " bloomers " occasionally seen abroad. Costumes for games are not luxuries, but necessities, and unsuitable foot-gear may be dangerous.

Formerly, advice to girls was to wear hair in a couple of plaits, but, for health purposes, the present fashion of cropped hair cannot be improved among growing girls.

Excusals from Exercise.—All children should be exercised except under particular circumstances. Reasonable exercise is a daily necessity and expected to improve children's alertness and mental freshness. By promoting blood and lymph flow, it aids in removal of fatigue products from other parts, for instance brain centres. From actual observation effects are greater with girls than boys.

It is easy to go to excess in exercise. During the War growth of cadets was shewn to be less than of controls not doing so much heavy work (*S.H.*, 1918. 22).

Schiötz in Oslo has devised a means of classification on physiological grounds. His competing age for athletic sports is the mean of a chronological, height, and weight age. His height age, for instance, would be the age at which the boy's height was the average (*J. of S.H. and Phys. Ed.*, 1924, Autumn).

No case should be excused physical training without definite grounds, or for more than twelve months. Excusal should be temporary, and grounds of excusal stated in writing, and date of review assigned.

Some children are unfit for violent exercise of games because they are debilitated and ill-nourished. They should be excused whilst this is investigated. If that has been done exercise may aid recovery. Continuous easy work is best for them, not heavy spurts. Children under-nourished and debilitated, with an easy school

FIG. 20.—OLD SYSTEM. "BELOW 15" (i.e. $13\frac{1}{2}$—15).

hron. age	17	17	16	16	16	16	15·5	15	15	15 (14·8)
eight age	16	15	16	16	17	16	16·1	17	16	16 (15·8)
Veight age	15	15	16	15	16	16	18·4	17	17	16 (15·8)
	16	16	16	16	16	16	16 (16·7)	16	16	16 (15·47)

FIG. 21.—SCHIÖTZ NEW SYSTEM. "COMPETING AGE" 16.

journey of six to eight days, gained more than controls. Gardening is a good occupation for these children, where it is available.

Cases of sharp-faced, overworked children, who for a second are alert and then relapse into the passive condition of the little prig, are illustrated best by the weary, pale-faced youngsters who have their childhood stolen from them, by misguided but pious parents, to study the Law and the Prophets. No such case should be passed over, they are worth saving, but unfit for intellectual work till conditions have been remedied.

Shortness of breath is a great sign of heart weakness. A child shewing this requires its exercise tolerance carefully estimated and its heart condition recorded. It may be due to anæmia and some exercise may be beneficial. Convalescents from any acute disease require careful handling. Resumption of school attendance should not be pressed. Permanent damage may come to convalescents from zymotics. Death from heart failure is a notorious risk in diphtheria cases apparently on the road to recovery. Measles and scarlet fever are other cases where the heart may be suspect, and tonsillitis may be a most severe disease in its after-effects. In these cases, rapidity of the pulse is a rough indication of want of recovery.

A pulse regularly over 100 in older children contra-indicates ordinary exercises. Tubercular children, or rather stages when tubercle is almost latent, may be damaged by violent exercise. Chorea recently, that is within the past four months, should prevent exercise, except on a definite medical certificate.

Other rarer conditions, requiring temporary exclusion till a definite medical judgment is recorded, are boys with ruptures. Children who suffer from asthma, giddiness, migraine. Those who belong to families of bleeders, should only exercise with caution.

Any child with myopia over 6 D. has to be warned about violence lest detachment of retina occurs. The writer has only seen it once from this cause. Chronic abdominal pain, if recurrent, may suggest appendicitis or tubercular glands.

Girls with full necks and fine tremor of fingers or rapid pulses are better for a time away from exercises. On the other hand, many adolescents supposed to have heart troubles are quite tolerant when tested, and benefit by further exercise.

In excluding from exercise the child should be told why it is excluded, and warned that it must be careful out of school as well. A scholarship boy seen by the writer was excluded from exercise six months previously on account of rheumatic myocarditis affecting both aortic and mitral valves, and now found to be conscientiously avoiding all games, but employing his spare hours cycling, one of the hardest heart tasks.

There appears no reason why a child suffering from epilepsy so infrequently as to be in school, should not do ordinary exercises

except high apparatus work or swimming, where an attack might have serious risks. Plenty of heavy exercise has the reputation of being good for epileptics.

At early ages the same exercises suit both boys and girls. With development of puberty, the girl will have modifications required by her structure. The development of the breasts exclude her from violent games where knocks and possible injury may happen, thus definitely putting boxing and football out of the field for girls. Feminine nature calls more for graceful, emotional movements rather than rude strength, but all Ling free standing work will be good, and especially balance exercises.

Where possible, swimming is also one of the finest physiological exercises, especially for girls.

It is usual to allow girls who desire it to plead headache at menstrual periods, but consensus of opinion is that except in rare cases, exercise may be freely practised at those times. Dr. Clow (*Journ. of School Hyg. and Phys. Educ.*, July 1923) advocates as a powerful prophylactic against dysmenorrhœa the regular persistence in physical exercises.

Much trouble which arises in adolescent girls appears the result of suggestion. Dr. Poul Hertz of Copenhagen, at the Paris Congress in 1910, had found high apparatus work causing headache, nausea, giddiness, and even vomiting; he noticed that more than half the number had poor or absent pharyngeal reflexes, and two-thirds had localized anæsthesias.

The soundest criticism about girls' exercises is that with ordinary exercises, the physiological tendency of many to genu valgum easily leads through foot placings and turning outwards of the toes, to weakness in feet, and ultimately flat-footedness. Tip-toe dancing and skipping ropes should be part of physical work for girls of all ages.

Exercises should be made purposeful. The work is spread wider over nervous areas where it is purposeful, and probably there is less fatigue of any particular nerve cells.

During the War, purposeful exercises were found to have much advantage over mere drills, and in the Air Force, exercise was set out as a set of almost positive games. It is in this way that play comes to be of such educational value to the child. The main thing is to provide exercises which have something attractive in themselves which will give satisfaction, and be carried on into adult life. It is essential in competitions that all the professional and commercial elements, which seem to be the curse of American exercises, should be excluded. They should make sportsmen, not "sports," and that hitherto has been the chief claim to distinction which English Public Schools have maintained.

Manual training from the exercise point of view has the advan-

tage, too, that as exercise it is subconscious. The school journey is a very complex educational instrument, but in it exercise plays a great part.

The apparatus required by the writer is simple for primary schools. The plank, adjustable to level or sloping, flat or on edge, and a few graduated stools for the youngest children to jump from. The " junglegym " introduced at Deptford and in Detroit baby-rooms is valuable. Otherwise the exercise is play, games, marching, running, skipping ropes, hopping, dancing, turning cartwheels, and some free standing Swedish movements, dull and dreary though these last may be to most children. For older pupils a gymnasium is required, provided with high and low plinth, horizontal ladder, Swedish balance form with hooks, and ribstalls. Other gymnasium fittings will depend on requirements of the teachers.

CHAPTER IV

PLAY

The eleven-year-old who as a school task wrote, " Keep off the grass is used too many times. There is too much education going on nowadays, and the man who makes boys go to school till they are sixteen wants dealing with," voiced the cry of the primary scholar for play.

The play instinct is Nature's educational means, and formal education for requirements of civilized life comes late on the scene, and has to be interpolated with as little interference as possible into natural education.

Play is neither relaxation nor working off of superfluous energy. It is the cry of developing muscles and nerves for function, which has to be answered. As soon as a child is awake it wants to play, and it will play, if allowed, till it is tired and wants to sleep again. The younger the child the more is this rhythm followed. Its contact with its fellows, at first one or two, then more, builds up naturally conditioned reflexes necessary for social comfort (p. 319).

Children's play is not always conducted as adults would desire, nor is it restricted to exercise rooms and playgrounds. Passages and stairways, walls and roofs, stables, docks, railway stations, bridges, cellars, wherever children can get, are their playgrounds.

Ascetic ideals, developed out of unwholesome lives by verminous saints, accentuated the doctrine of the unclean body, and made play neglected as a social activity. We might go farther back to an ancient prophet whose vision reached to a new Jerusalem, one of whose glories was : " The streets of the city shall be full of boys and girls playing in the streets thereof " (Zech. viii. 5).

Restriction of wheeled traffic in by-streets and culs-de-sac for some hours daily, for children's games and play in safety, is a sanitary requirement for healthy living in all great towns. The child wants space and safety. It will not go half a mile to a playground, therefore make the side-street safe for some hours daily.

Renaissance education was uselessly ornamental in literary type, and its gradual failure and want of replacement by other subjects preserved the great Public Schools. It is said that arithmetic

was only introduced at Eton in 1840. This neglect allowed games to grow up so that an English Public School boy is now educated in a more natural and healthy way than any other child.

The old sectarian schools neglected health of the body very much, and absence of sufficient play space was general. School play only seemed realized with popular education. Full recognition of need came in a Report of a Committee of the Board of Education in 1912, that 30 sq. ft. per head was necessary for older children, and 16 sq. ft. for infants, as playground space. Even this is absurdly small as a requirement. The want of earlier school provision the Report proposed to amend, and suggested that after 1920, playgrounds allowing less than 10 sq. ft., and after 1925 less than 15 sq. ft. per head, should be deemed insufficient.

The nursery school is mostly play, at first almost alone, then in twos and threes ; youngsters find happiness in activity. The very young child has little power of combination with others and no initiative. It has to be shewn how to employ itself. Indeed, all children's play must have adult guidance, either on the spot or in rules and regulations of well-thought-out games or contests. Playing the game according to ideal custom and rule is the great educational feature. To get the best out of the time, a good leader is needed capable of looking after 500 children, and the distribution of the playground load throughout the day needs organization.

The late Mrs. Humphry Ward organized play centres for after school hours, where children in more densely populated quarters could come and find warmth and shelter, friendly grown-ups, comradeship, toys, and recreational occupations. This effort of the organizer was much needed, as children were found locked out of their homes for hours. One manufacturer asked for provision of a play centre because children used to come down to the factory gates, and cry till their mothers came out. These centres, in freedom of choice and occupation, have immense moral value. Mrs. J. P. Trevelyan has written a good description of this work (Methuen & Co.).

Play centres for the vacations have been of great value, too, in quarters remote from parks or open spaces and in wet weather. Bathing and swimming should also be made available for children. It was also a companion school boy whose essay suggested that "every town should have a canal through it."

The general doctrine of play is that two or three hours a day should be the aim at the start of school life, coming down to about an hour a day at the end. This is the adult requirement for play activities in sports, to remain physically fit.

Luther Gulick has written *A Philosophy of Play*, and Curtis

examines the whole topic, both administratively and educationally, in his book on *The Play Movement* (Macmillan).

The essential play activities of Boy Scouts and Girl Guides represent the greatest educational advance towards healthy bodies and well-balanced minds, which has come since popular education began. It is also natural education by doing and thinking, instead of talking about symbols of things.

CHAPTER V

NUTRITION

The life of an organism is manifested in the metabolism of its cells. Nutrition and growth are the building up of complex protoplasmic materials whose combustion results in production of muscular movement, of heat, and of various simpler chemical bodies as secretions or waste products. The sum of these last changes may be regarded as chemically equivalent to oxidation.

The law of conservation of energy holds in the chemical and physical changes which constitute the process of living, and although efficiency of the body as a machine is only 20 to 30 per cent. of the energy supplied, yet intake of energy as food is exactly proportioned to energy expended in movement, heat, and waste products.

Any discussion of nutrition or food requires some quantitative estimate of energy taken in or given out. This can be stated in a common measure as heat units.

The standard unit of heat on the C.G.S. system is the calorie; the amount of heat required to raise the temperature of one gram of water from 15 to 16 centigrade. This is a comparatively small amount, and for convenience in physiological and dietetic studies the large Calorie, spelt with a capital initial, is generally used; it is a thousand times greater.

The amount of energy in food can be expressed in Calories produced by its combustion, and the amount of energy expended can be equally measured, for one Calorie represents 424 kilogram metres. A certain minimum amount of energy is required for the mere process of living, apart from any external work, or from heat given off. This is a fundamental measurement, a datum above which all other amounts must be reckoned.

For years observers have tried to measure this energy necessary to maintain life, but satisfactory work is of recent date.

The Basal Metabolism.—The first important work is that of Forster in Munich (1877), using Pettenkofer and Voit's calorimeter chamber.

They determined the proportional basal metabolism of children as double that of adults. Speck (1889) at Leipzig; Tigerstedt (1895) at Stockholm, used school children; Magnus Levy and

Falk (1899) in Helsingfors (*Arch. f. Anat. u. Phys.*, 1899, Supp. 314); Rubner (*Beiträge z. Ernährung im Knabenalter*, Berlin, 1902), and various other workers have contributed to the difficult question, but modern data are those of Dubois who, using the respiration calorimeter, studied oxygen consumed, carbon dioxide given out, and heat produced in a very exact way.

The work of Benedict and Talbot, commenced in 1913 at the Massachusetts Hospital, and summed in Carnegie Institute Publication 1921, *Metabolism and Growth from Birth to Puberty*, has now considerably cleared up the subject.

Determination of basal metabolism in the adult within the last few years has been made so convenient and accurate that it can be used for clinical purposes. It is almost an ideal that is sought, as so many other factors evade complete elimination.

The determination is made by carefully measuring rate of gaseous exchange per hour, in proportion to the bodily size and configuration. Earlier work neglected food absorption from the stomach, which materially increases metabolism, and also muscular movements which affect the result. This is now corrected by taking measurements during rest in the post-absorptive period of digestion.

Measurements for long periods, say 24 hours, would err in including other factors than basal metabolism. Periods as short as is consistent with error of experiment are consequently used.

As individuals vary in size, obviously the gaseous exchange and heat given out will vary accordingly. The basal metabolism must therefore be reduced to some common measure such as kilogram of body weight. Clinically it is easily given as Calories per square metre of body surface. Basal metabolism has little relation to heat given off from the surface, or the temperature of surroundings would have to be regulated carefully. The area of skin surface is taken not because of heat escape, but because it is proportionate empirically with the mass of living protoplasm.

This idea is borne out by the work of Putter (*Zeit. f. Allgem. Phys.*, 1911. 125), where the exchange for different animals varies so much that evidently the skin area is not the determining factor. Maintenance of temperature is directly dependent on metabolism, and with greater loss of heat through the skin the metabolism has to be increased to maintain the flow of heat and keep the body at the normal temperature, but this is more than basal metabolism.

In considering young children and their clothing, skin area comes in as a surface through which there is proportionate loss of heat, but here also it is only an empirical expression for mass of protoplasm.

Basal metabolism is, therefore, measured with the individual

in bed, preferably before morning food has been taken, and the skin just cool enough to prevent heat accumulation, which alters metabolism. If there is any excess of heat removal, metabolism is correspondingly increased above the basal metabolism, which is also about 15 per cent. less when asleep than when awake.

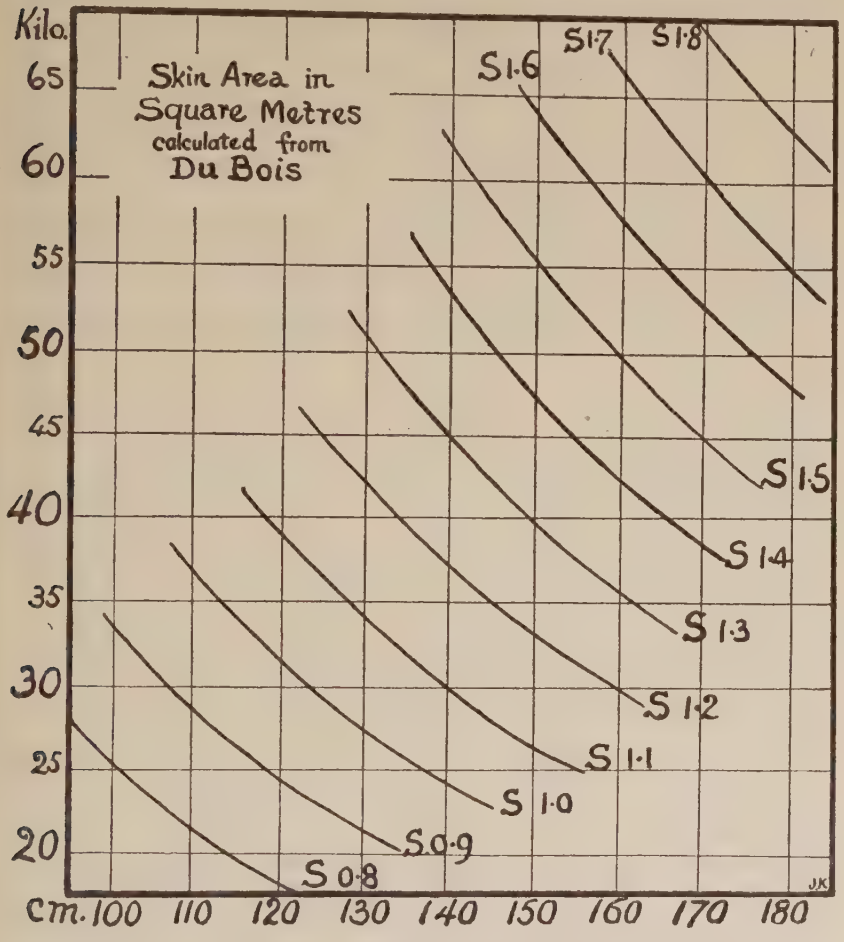


FIG. 22.—DIAGRAM TO FIND SURFACE AREA OF SKIN FROM HEIGHT AND WEIGHT. (DUBOIS'S FORMULA.)

Flack and Hill noted an increase of 27 per cent. in metabolism when sitting in ordinary clothes in a warm room, raised to 82 per cent. when sitting in open air. This stimulus to metabolism is of great importance to health.

Dubois (*Arch., Int. Med.*, 1915. 868), by a series of carefully measured casts, has determined skin area S in square metres to be related for persons over ten years of age to height H in cm. and weight W in kilos, as $S = 0 \cdot 007184 \times W^{0 \cdot 425} \times H^{0 \cdot 725}$.

Fig. 22 has been drawn to illustrate the relations of heights and weights, as taken, for instance, from Table 11, with the corresponding surface areas of the skin as calculated by Dubois's formula. By inspection any other values in school children can be interpolated with sufficient accuracy for school purposes.

Another simpler formula given by Lissauer (*Jahr. f. Kinderheilk*, 1902, N.F. 58. 392) is $S = k\sqrt[3]{W^2}$. The constant k he gives as 10·3, but Benedict corrects it to 10·0 for boys and 10·1 for girls below 6 kilos; from 6 to 15 kilos, he gives 10·6 for either sex; from 15 to 25 kilos, 11·2 for boys and 10·8 for girls, and above 25 kilos, 11·5 for boys and 11·1 for girls, these values falling within 3 per cent. of other measurements.

Professor Dreyer expresses the basal metabolism by the formula $\frac{W^n}{C \times A^{0·1333}} = k_1$, where n is approximately 0·5, and k_1 for males is 0·1015 and for females 0·1127, A being given in years old, and

TABLE 34.

Mean Age of Boys (x).	Numbers.	Basal Metabolism.	
		Actual.	Smoothed (y).
6·5	4	57·5	57·5
12·6	4	50·4	48·7
13·7	4	49·4	47·3
16·5	8	43·0	43·9
19·25	7	40·7	40·7

C the number of Calories produced in four hours. This shews that basal metabolism is not necessarily a function of skin area (*Lancet*, August 7, 1920).

In healthy individuals basal metabolism stated in Calories per hour per square metre of surface works out as about 40 for an adult man and about 57·5 for a child of six or seven, the child's metabolism including energy of growth.

Dubois, from a series of experiments, found the figures as given in Table 34.

The formula used for smoothing was $\log y = 1·8362 - 0·0118\,x$, and by its means the basal metabolism can be interpolated for any other age in the series.

From this table of Dubois, the average food requirement to cover the basal need of the child would range in available Calories from approximately 1000 Calories, at the age of 5, to about 1500 at the age of 14; whilst the basal metabolism of the woman is only 0·93 that of the adult man, there are no measurements to shew

that the girl differs in need from the boy, especially as in later school years she is growing more quickly.

Measurements of groups of Girl Guides aged 12 to 17 years, according to Benedict and Hendry, shewed the requirement about 55 Calories per hour, and 1250 Calories for 24 hours as basal metabolism. Heat production per kilo of body weight fell regularly from 29·9 at 12¾ years, to 21·7 Calories at 17 years.

The Royal Society Committee give a statement of effect of posture which is an addition to basal mechanism and proportionate to it. Sitting increases the amount recorded 5 per cent.; standing relaxed, 10; hand on a staff, 11; standing leaning on a staff, 3; and standing "attention," 14 per cent.

Energy as Food.—Adding 10 per cent. for unutilizable food values, the food requirements for a man of average size following different

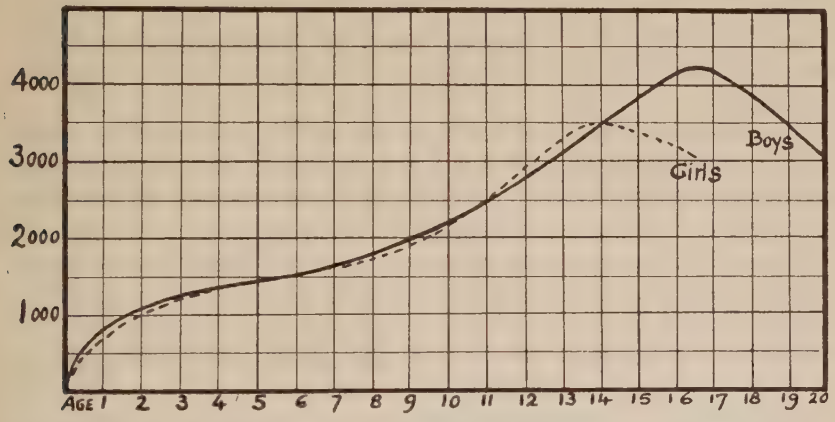


FIG. 23.—FOOD REQUIREMENTS OF CHILDREN IN CALORIES. (HOLT.)

occupations might be set out in Calories: Tailor, 2750; shoemaker, 3150; painter, 3600; stonemason, 4850; wood-cutter, 5500 Calories.

Schoolboys (age 13–16), reported by Gephart, used 5000 Calories (page 132).

Emmett Holt puts it roundly that during school-life boys require 80 or more Calories per kilo body weight, whilst girls require just up to 80 Calories per kilo. In his book on *Food and Health*, p. 80, he gives a table of the daily Calories worked out from a hundred children.

Whilst investigation of the energy requirements for healthy life is one way of approaching the subject, it still presents many difficulties for determination of necessary diets. Most of the world in the Great War had experience which led to an enormous advance in knowledge of food and diets. Certain materials, from

an estimate of their energy value, would be almost worthless, but clinical results shew them indispensable for growth and life.

The statement of the value of a diet purely in Calories is therefore not sufficient. Habit and custom play a large part, and emotional and æsthetic conditions materially affect appetite and nutrition. The adequacy of any diet means that the individual must be maintained thereby in full physical growth and vigour. The diet must have a sufficient stock of energy in its caloric value. It must contain due proportions of proteid, of carbohydrate, fat, salt, and the hitherto indeterminate bodies known as vitamins. It must correspond to the dietetic habits and wants of the consumer.

The element in food which most frequently fails is proteid. Proteins are albuminous bodies produced by organisms, animal or vegetable, in their structural growth. Proteins vary enormously in their food value, those from animal sources being more effective than vegetable forms. Thus Berg found that for an adult it would require 10 lb. of haricot beans daily to give the requisite protein.

McCollum states that the protein of ripe peas, beans, and lupines is insufficient. Proteins are of very complex structure, containing various " amino " acids which are necessary in nutrition. The zein, the protein of maize, contains no tryptophane, an " amino " acid, one of the group ; and an animal cannot be kept alive on zein, unless tryptophane is added. So, too, gliadin, the protein of wheat, suffices for maintenance but not for growth. Proteid materials contain most of the nitrogen of the food, and although they vary so much among themselves they cannot be replaced by other materials. The proteid elements are required for structural growth, they used to be called " flesh formers."

Energy required for heat or structural growth can be derived from oxidation of fats or carbohydrates, which in this respect are largely interchangeable, but for structural wear and tear of the tissues a certain quantity of proteid is a fundamental requirement.

Voit worked out in Munich the protein requirement for a man as 118 gm. daily ; woman, 90 gm. ; and this has been accepted for many years. Pearl, from his own enquiries on food, estimates a man as consuming daily 114 gm. protein, 127 gm. fats, and 433 gm. carbohydrates, giving 3423 Calories.

The United States Department of Agriculture, studying dietaries of families, found an average of 95 gm. protein. Probably 100 gm. may be taken as a sufficient average. Any mixed diet with a daily value of 3300 Calories almost certainly will not have less than the minimum of proteid necessary. One gram of proteid is about equal in energy to 4·1 Calories.

Characters of Foods.—The Royal Society Committee stated the

minimum requirement of protein as between 2½ and 3 oz. a day, or equal to that contained in 2 lb. of bread, 18 oz. of meat, 10 oz. of cheese, or 10 eggs.

The cheapest form of protein obtainable can be got in the form of milk, so necessary for growing children.

Chittenden shewed that with chosen proteids, the proteid under favourable conditions could be reduced to about half that usually considered necessary to maintain life. Proteins are also the most convenient form for the rapid production of heat and work. The Esquimaux, amidst snow and ice, uses eight times as much proteid as the average European. Children, like other young animals, do not grow well on low protein diets.

Carbohydrates are mainly comprised in the starches and sugars. A gram of carbohydrate may be taken as equal in energy to 4·1 Calories.

They form the bulk of diets and are the cheapest foods, so that in the diet of the poor, and often in diets ignorantly but economically provided, they form an excessive proportion, causing deficiency in more expensive proteids. These last should not be less than a fifth of the energy proportions of the carbohydrates of the diet.

School feeding, unless carefully supervised, tends to err grievously in this respect. According to one of the pioneers in later work (Funk, *Med. Rec.*, June 10, 1916), food largely composed of carbohydrates accelerates signs of deficiency disease. Sugar is particularly useful as a source of muscular work, being easily absorbed. It was prized for this purpose in the German Army before and during the War. On the other hand, consumption of sugar by itself, as sweetmeats apart from regular meals, is generally condemned, especially by dentists, as bad for children. It may also affect their appetite for meals. The objection is probably more prejudice than reason.

Fats, weight for weight, contain more energy than other foods, often double that of carbohydrates. One gram of fat has energy value of 9·3 Calories. Fats are not necessities for life, but they are exceedingly economical in use. The Royal Society Committee decided during the War, that 16 oz. of fat weekly per head should be deemed the required provision. Extensive dietaries have been constructed abroad during the War, assuming that fats and carbohydrates were interchangeable. Strassburg geese can be fattened on carbohydrates till they are ready to be used for *pâté de foie gras.*

Animal fats generally carry certain accessory substances already mentioned, and may be more useful in this respect than for actual energy value. These substances, however, occur in other foods. They are spoken of as accessory, as very small but definite amounts are necessities. They are separately mentioned as vitamins later.

Salts are present in all diets, and are absolutely necessary, although their relations are not yet worked out; for instance, apart from vitamins a keratomalacia has recently been described due to want of balance of dietary salts. This want of balance may even come about through excess of some constituent; thus potassium seems to wash out sodium; and excess of magnesium to cause deficiency of calcium. Other changes are suspected due to saline constituents.

Prevalence of thyroid enlargements in districts about the Great Lakes in America and in Switzerland has been met by addition of traces of iodides to the diet. Calcium salts and phosphates are of great importance, and iron which occurs in most foods.

In the majority of diets deficiency in salts is unlikely. Calcium has to be easily taken up, and recent studies state that milk is the best source, but for this each child would require a quart a day.

Table 35.

Atwater's Standards.	Amount in Grams of Dry Substance.	Calories Energy Value per Gram.	Total Calories.	Total Energy in Calories.
Protein	125	4·1	512	3500
Carbohydrates ..	500	4·1	2050	
Fat	100	9·3	930	

Studies on rickets suggest that the value of cod-liver oil is largely associated with its power of promoting calcium assimilation. In regions where water is poor in lime, it is indispensable for children to be given ¾ pint of milk daily. To secure chemical bases in any diet, about five to seven times as much vegetables, potatoes, and salt-rich fruits should be given, as of meat, cereals, or eggs. It is important to secure a sufficiency of bases. The quantities of the several categories of food require careful estimation. This can only be done closely as the result of clinical experience.

Quantities of Food.—Atwater adopted a standard of 48 gm. protein and 30 gm. of fat for five-year-old children. Chalmers Watson (*B.M.J.*, March 1913 and August 1918), from continued observation on eight healthy children, gives 72 gm. of protein and 69 gm. of fat, with 198 gm. of carbohydrates, working out at 1725 Calories. He found children with tubercular tendencies require still more protein; casein of milk, for instance, being of greater value than protein of meat.

Chittenden's tables are of minima possible to live on, but they

are too low for the rough and tumble of life and the maintenance of full immunity to common infections.

Atwater's standard diet is more satisfactory and varies according to work done from 3000 to 3500 Calories. A man doing moderate work would require amounts as in Table 35.

For children, he gives at age 1–2 an amount 30 per cent. of adult need; 2–5 = 40 per cent.; 6–9 = 50 per cent.; 10–13 = 60 per cent.; and 14–16 = 80 per cent.

These are rather low, but Schröder gives for Institution diets in Germany still lower totals, although his protein is greater.

Later statements, for instance, Leonard Hill in the Blue Book (Cd. 8798, 1917), says that boys and girls over 10 years old require as much as men and women. Dubois (1917) shews that boys in training camps require 25 per cent. more than adults.

Pembrey (*School Hygiene*, 1915. 99) gives the following—

TABLE 36.

	Dry Grams Protein Daily.	Grams Fat	Grams Carbohydrates.	Total Daily Calories
German Institutions (Schröder)—				
Children 8–9	60	44	150	1270
12–13	72	47	245	1737
14–15	79	48	270	1877
English Institutions—				
L.C.C. Industrial boys over 8 ..	88	66	377	2515*
Boys of Royal Navy	107	69	406	2745
Secondary Schools (Dukes)—				
9–14	123	97	430	3400
14–19	—	—	—	4800
Duke of York School	157	206	472	4515

Dr. Friend, as a result of half a dozen years' work at Christ's Hospital, adopts 3200 Calories for the fourteen-year-old.

Camerer (*Der Stoffwechsel der Kinder*, Tübingen, 1894) worked out the diet for his own children as needing for each kilo of body weight—

TABLE 37.

Age.	Sex.	Proteids, Gram.	Fat, Gram.	Carbohydrates.	Calories.
2–4	B.G.	3·6	3·1	9·2	75
5–7	G.	3·0	1·9	10·7	69
	B.	3·5	2·5	10·9	76·6
7–10	G.	2·7	1·3	9·9	39·2
	B.	2·8	1·3	10·4	61·6

* In 1918 the dietaries (adolescents) were raised on suggestion of the Home Office Inspectors to 3000 Calories.

Emmett Holt and Fales (*Amer. J. Dis. of Children*, 1921) shew how the child differs from the adult. The total metabolism in Calories appears about 100 Calories per kilo, at one year, when the weight is 9·5 kilo ; for boys of 6, with weight about 20 kilo, it is 80 Calories, then constant till 15. In girls of 6, about 76 Calories, and remains at this till the tenth year, then is 80 till growth is finished, when it falls to 44, the adult figure. According to this the daily requirement of children during adolescence exceeds by 1000 Calories, or nearly one-half that of an adult of average activity.

Diet may be sufficient and adequate to keep life going, but it is obvious in many districts that children's mentality is below what it should be in school work, and want of better feeding seems the most probable cause. Sherman and Campbell (*Journ. Biol. Chem.*, 1924) discuss this question. Diet in animal experiments may maintain apparent health, but the animal cannot breed. It may be sufficient for reproduction, but the animal is unable to suckle its young, or it may suffice for both these functions and yet the animal age prematurely.

For diet adequate for the above purposes addition of milk shewed improved efficiency, in that the animal added more weight per 1000 Calories of food, the average size at all ages was greater, maturity earlier, and senility deferred. There was also better growth of the young during the suckling period, so that what is wanted is an optimum diet, which gives the best results attainable.

Still we have the C.O.S. ideal cutting down milk for children in schools to the half or three-quarter pint for the most necessitous.

The Amount of Fat in Children's Diet.—Holt and Fales found that older children (*Amer. J. Dis. of Children*, 1922. i. 471) required an average of more than three grams of fat per kilo when under six years of age, and about three grams during the rest of growth. They think that children at one year should have four grams of fat daily. Reduction of fat in food appears to predispose to infections like tuberculosis, and to reduce calcium metabolism. They found that healthy children left to themselves select about half their diet in carbohydrates, one-third fat, and one-sixth protein.

During the War the importance of fats was closely examined. German workers endeavouring to replace them with carbohydrates.

Starling states that in the absence of carbohydrates, proteins are broken up, and fat sufficient to replace carbohydrate would cause acidosis. On the other hand, carbohydrate without fat causes water to accumulate in the tissues, and dropsy.

With the high caloric value needed in heavy work or outdoors or in cold climates, the intestines cannot deal with necessary carbohydrates, and for efficient digestion alone, at least 20 to 30 per

cent. of the Calories must be as fat. In American lumbermen, doing heavy muscular work and using 8000 Calories daily, the fat runs as high as 45 per cent.

The food values adopted by the Inter-Allied Commission were—

TABLE 38.

	Age in Years.	Daily, Gross.	Calories, net.	Fat, Grams.	Percentage Fat, Calories.
Children	0–6	1650	1500	62	35
	6–10	2310	2100	62	25
	10–13	2750	2500	74	25
Boys	13–20	3300	3000	88	25
Girls	13–20	2750	2500	74	25
Average Worker	adult male	3300	3000	70–80	20–25
	adult female	2750	2500	60–74	20–25

Chalmers Watson's estimate of fat for the child of five, works out at 34 per cent., in close agreement with this table. His Caloric value 1725 is more reasonable than that of 1270, worked out from Atwater's tables.

For health, diets must not be cut finely. Germany was a starving nation in 1916–17, living on 2000 Calories per head, of which 64 per cent. was bread. The weight of the civil population fell 9 per cent., and every possible exercise had to be avoided; children were kept in bed. Castaldi, an Austrian physiologist, when prisoner, found existence possible on 1700 Calories, but there was physical and mental impairment and recuperation only came with improved diet.

Sylvester-Bradley (*B.M.J.*, 1923. ii. 925) gives the rule $(H - 3)^2 = C$, where H is stature in inches and C large Calories for diet.

Although food deficiency may be made up later, the results of hunger strikes on the sufferers suggests the possibilities of permanent changes, and in the earlier years of life diminished growth is not fully made up. One was particularly struck with post-War Viennese children (1920) in robust health, but appearing two or three years younger than they really were.

Vitamins the Accessory Factors in Diets.—It had been known for generations that human beings living with an absence of fresh food became more liable to disease, and that in besieged towns or among men on ships sailing for months without fresh food, scurvy was apt to occur. Captain Cook discovered that fresh fruits, or vegetables, even in small quantities, prevented this.

About 1906 Hopkins of Cambridge prophesied the discovery

of some accessory substances in diet. More recently, another disease, beri-beri, found among rice-eating peoples, was associated with deficiency of the coarser parts of the rice grain. This was the type of deficiency disease first demonstrated through beri-beri produced in pigeons. When fed on polished rice grains, till dying of neuritis from this cause, and unable to stand, pigeons were revived by injection of a small quantity of polishings, which caused a rapid recovery to health. The vitamin present in polishings waste is soluble in water, and is commonly referred to as anti-neuritic vitamin or water soluble B.

The so-called scurvy rickets, described by Barlow as occurring in infants fed only on sterilized milk, shews a similar rapid cure with a few grapes or a little orange juice. This is also due to a vitamin in these vegetable materials and in normal milk.

The anti-scorbutic vitamin or water soluble C is present in fresh, but destroyed in heated milk.

By animal experiments and confirmed by clinical observation, as in Barlow's disease, the existence of several varieties of these specific bodies, the vitamins, has been postulated. They have not yet been isolated, or indeed, separated chemically. They exist in minute quantities, appear very unstable, and in their physiological rôle can be easily destroyed. Three or four such bodies have been recognized. The two already mentioned, and another associated especially with animal fats, the growth vitamin or fat soluble A.

Fat soluble A seems the chief medicinal agent in cod-liver oil, in which it is said to be more than two hundred times as abundant as in butter. It occurs in milk, butter, eggs, in beef fat and the oleo oil from it, also in margarines, but only those with animal fat as basis. It is scanty or absent in coco-nut oil and vegetable oil and fats ; lard is also destitute. A sufficiency is an absolute necessity for growth, and its want or scarcity causes defects in the tissues. K. Takahashi claims to have isolated vitamin A in a nearly pure state, containing 81 per cent. carbon and 10 per cent. hydrogen but no nitrogen, he regards it as an aldehyde (1923).

The extraordinary value of milk vitamin for growth was demonstrated by Hopkins (*Journal of Physiology*, 1912. **44.** 433). Two sets of eight rats each fed on similar diet, except that one set had 2 to 4 c.c. milk each daily, marked on the chart by white circles, the others had no milk, marked by black dots. The first lot gained weight, the others lost weight. The milk was then altered, and immediately those which had been losing weight, now, with the tiny dose of milk, began to put on weight. Meanwhile, the first lot that had been on milk, on its discontinuance at once began to lose weight, as illustrated in Fig. 24.

So far back as 1904, Mori, in Japan, called attention to eye

troubles of young children in times of famine. There was set up a condition due to softening of the tissues, and their invasion by germs (*J.A.M.A.*, August 1922). This only occurred in vegetarians.

C. E. Block (*Journ. of Hygiene*, 1921. 283) described cases in Copenhagen in children living on skim milk. During the war-export of butter, it became frequent in Denmark, ceasing when butter was rationed. The season of occurrence also agreed with Malling Hansen's season of growth in height, more vitamins presumably being required for growth. The disease is seen occasionally in this country. Cases seen by the writer have been from

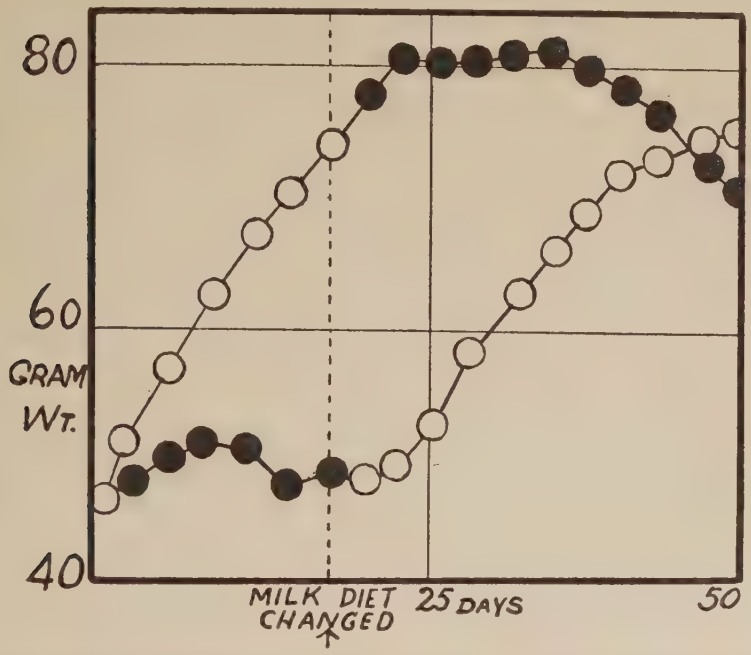


FIG. 24.—MILK VITAMIN AND GROWTH OF YOUNG RATS. (AFTER HOPKINS.)

industrial schools, and of Irish extraction, but they were not then correlated to dietetic errors, although similar cases in adults with night blindness had been put down to poor nutrition as a contributory cause. Besides this ophthalmic trouble, deficiency of fat soluble A appears to reduce resistance to bacterial disease. It also plays a part in the development of the dental tissues.

This vitamin resists moderate heating, so that a considerable percentage remains in pasteurized milk. The Report of the Medical Research Committee states that it is gradually destroyed by heat, and that four hours' exposure to heat rendered butter of little better value than lard. Keeping dried milk also slowly destroys the vitamin in it. Hopkins found vitamin A sensitive to oxygen,

and suggests that exposure in shallow pans to heat and oxygen is why lard is free of vitamin.

Water soluble vitamin B, anti-neuritic vitamin, is also necessary for growth and possibly for normal functioning of lymphoid tissue. It is only slowly destroyed by heat, half an hour boiling will destroy about half of what may be present. It is found in milk, oats, wheat, barley, maize, beans, cabbage, tomatoes, and so on.

Vitamin water soluble C, referred to as the anti-scorbutic vitamin, is present in fresh fruits and vegetables, potatoes, and germinating grains. It is abundant in canned or fresh tomatoes ; it is also in small quantity in fresh milk, but although present, is scarce in fresh meat. It is least stable of vitamins and quickly destroyed by heat. Overcooking or stewing vegetables destroys this factor. It is present abundantly in orange juice, of which 1·5 c.c. has about as much of this vitamin as a pint of fresh milk. Experimental work suggested that summer milk had more vitamin, particularly A, than winter milk, but McCollum has shewn that this effect is due to sunlight which can act as the equivalent of a certain amount of vitamin in preventing rickets. There may, indeed, be a fourth anti-rachitic vitamin, a fat soluble body in cod-liver oil, vitamin D, but this has not yet been thoroughly worked out. Irradiating milk in shallow pans, 3 ft. from a quartz mercury vapour lamp for 20 minutes, increases its anti-rachitic qualities remarkably (*B.M.J.*, 1925. i. 594). Hess has worked out that effect of irradiation is chiefly on cholesterol, and that excess of radiation abolishes its useful effect in promoting nutrition (*J.A.M.A.*, 1925. i. 687). He localizes the anti-rachitic rays as 300 $\mu\mu$ to 313 $\mu\mu$ (*J.A.M.A.*, 1923. i. 687). This is discussed later.

The rôle of vitamins in diet is well described by McCarrison (*Studies in Deficiency Disease*, p. 210). "Vitamins are as the spark which ignites the fuel mixture of a petrol-driven engine, liberating its energy. The spark is of no use without the fuel, nor the fuel without the spark, nay more, the efficiency of the spark is dependent in great measure on the composition of the fuel mixture."

Cramer (*Lancet*, May 26, 1923) finds that vitamins act as food "hormones." Water soluble B seems to have a stimulating action on the lymphoid tissues of the digestive tract, as these atrophy in its absence. Fat soluble A is necessary for integrity of the intestinal mucous membranes, and also acts indirectly in formation of the blood platelets.

Inanition is the essence of all deficiency diseases, and on this may be superposed infections. Most chronic catarrhs of mucous membranes and skin surfaces, the corneal phlyctenulæ, and discharging ears are really results of mild deficiency disease, due to debility from insufficient nutrition. It is demonstrated by the

healing effect of meals and rest, of open-air schools, or even a cup of fresh milk in the ordinary school.

In children supposed to be thriving normally, to supplement diet by fresh vegetables always increases growth (R. Berg).

Chick and Dalyell (*B.M.J.*, 1920. ii. 546) studying scurvy in the Kinderklinik in Vienna, found the highest anti-scorbutic effect to be water soluble C in raw fresh lemon or orange juice, or in raw fresh cabbage leaves or their expressed juice. Calling this value 100, then fresh cabbage cooked at 100° C. for twenty minutes, was only 30, and cooked at 70° C. to 80° C. an hour was only 10. Fresh tomatoes or fresh turnip juice was 60, germinating peas, beans, or lentils were 30. Other fruits and vegetables and potatoes (cooked at 100° C. for 30 minutes) were about 7·5 and fresh cow's milk only 1·0 to 1·5.

Owing to proprietary interests pushing the sale of so-called vitamin-containing materials which, even from firms of first-class repute, were found when commercially purchased to be free from these factors, the American Medical Association published a useful table (p. 110) from which the main facts are extracted.

A large proportion of city dwellers suffer, especially at younger ages, from deficiency of vitamins. McCarrison states that loss of appetite is one of the most fundamental signs of avitamosis—a protective sign—the first signal of disaster which should at once excite suspicion about the food of any patient, and yet it is the commonest thing seen in children admitted to school feeding. Much urban debility is undoubtedly due to excess of preserved and cooked foods in the diets used. E. McCollum (*The Newer Knowledge of Nutrition.* Macmillan, 1919), who has advanced the knowledge of these substances so much, speaks of milk and leafy vegetables as protective foods. Milk has a protective value in improving the quality of diet which can be estimated only in terms of health and efficiency.

Some refining processes, as milling of flour or polishing of rice, remove layers containing vitamins ; prolonged cooking or preservation as tinned foods destroys them. Animal fats preserve them if not unduly refined by heating or oxidation, yet vegetable fats appear free from them. For these reasons Hopkins points out whilst brown bread and butter is a most excellent food combination, white bread and margarine is a radically bad one.

Tinned foods without salads are bad. Funk, who investigated the vitamin B, says that " A fortnight of canned food killed a dog."

Mellanby (*Rep. of Med. Res. Com.*, 1925) shows that for puppies cereals have ricket-producing powers, and there is an antirachitic vitamin in cod-liver oil, egg yolk, and milk.

The rachitic-producing substance is associated with the saponifiable part of fats, and antirachitic vitamin with the non-saponifiable

TABLE 39.

VITAMINS IN FOODS.

	A.	B.	C.
Bread, white (water)	?	+	−
Bread, white (milk)	+	+	?
Wholemeal (water)	+	+ +	?
Wholemeal (milk)	+ +	+ +	?
Barley, whole	+	+ +	−
Oats	+	+ +	−
Meat, lean	− to +	+ ?	+ ?
Beef, fat	+	−	−
Mutton, fat	+	−	−
Pig kidney, fat	+ +	−	−
Oleomargarine	+	−	−
Liver	+ +	+ +	+
Kidney	+ +	+ +	+ ?
Sweetbread	+	+	*
Fish, lean	−	+	*
Fish, fat	+	+	*
Fish roe	+	+ +	+ ?
Milk, whole (fresh or dried)	+ + +	+ +	+ V
Milk, skim or buttermilk	+	+ +	+ V
Cream	+ + +	+ +	+ ?
Butter	+ + +	−	−
Cheese	+ +	*	*
Eggs	+ +	+	*
Coco-nut	+	+ +	*
Tomatoes, raw or canned	+ +	+ + +	+ + +
Beans, kidney	*	+ + +	*
Beans, fresh stringed	+ +	+ +	+ +
Cabbage, fresh raw	+	+ + +	+ ?
Cabbage, cooked	+	+ +	+ ?
Carrots, fresh raw	+ +	+ +	+ +
Carrots, cooked	+ +	+	+
Cauliflower	+	+ +	+
Celery, cucumber	*	+	*
Dandelion greens	+ +	+ +	+
Lettuce	+ +	+ +	+ + +
Onions	*	+ +	+ +
Parsnip	− ?	+ +	*
Peas	+ +	+ +	+ ?
Potatoes, cooked	*	+ +	+
Radish	*	+	*
Spinach	+ + +	+ + +	*
Turnips	− ?	+ +	*
Apples	+	+	+
Bananas	+ ?	+ ?	+
Grape juice	*	+	+
Orange, lemon juice	+	+ +	+ + +
Prunes	*	+	−
Raspberries	*	*	+ + +

+ Vitamin present. + + Good. + + + Excellent.
− No vitamin. * Evidence insufficient.
? Doubtful as to presence or amount. V Variable.

part. Exposure of oatmeal either fresh or cooked, to ultra-violet radiation hinders its rachitic-producing powers. From this point of view wholemeal or white bread is probably unimportant (Mellanby). A yeast-growth factor associated generally with vitamin B has been isolated as a crystalline substance with definite melting-point 223° C. by W. H. Eddy (1925), of which 0·005 mg. in 1 c.c. accelerates yeast growth twenty-fold.

Variety of fresh and raw foods is most important, to avoid deficiency disorders of nutrition. Milk is the one indispensable food for children. Cereals are of value for vitamin B, and cabbage is a rich source of all vitamins. The great value of tomatoes and spinach is seen in Table 39. The nursing mother, too, needs vitamins for her child; they must be taken in, as they are not produced in the animal body.

Milk as a Necessity for the Growing Town Child.—Five-and-thirty years ago, Dr. Dukes, of Rugby, from actual observation, stated: "Milk should be bountifully supplied to all adolescents," and later declared that "boys under 14 required 10 pints a week." Every growing child needs from a pint to a quart of milk daily, may be taken as axiomatic in a modern child's nutrition.

Haven Emerson, in his Report (1924) on German children, sets out the value of milk. "The best single index and probably the most reliable material measure of the adequacy of children's nutrition in a modern municipality is the daily *per capita* consumption of milk." This is also the writer's experience.

In respect to milk all children are necessitous, and appreciation of this necessity has much increased since the War.

Long before this the extraordinary benefit of half a cupful of fresh milk given to debilitated children had been noticed in our school reports. Care Committees seem always to regard this milk ration as a waste to be severely restrained, whilst in reality it is the most economical and advantageous way in which a school child can be benefited. The amount of milk is generally restricted to half-pint a day, too little for full benefit to those most needing it.

An adequate milk supply, from studies recently carried out under the joint auspices of Columbia University and the New York Association for Improving the Condition of the Poor, is shewn clearly to be a full quart of milk a day, taken by the growing child to support normal growth with the best development of the bones and teeth (Professor Sherman, *A. Phys. Ed. Rev.*, 1923. 462).

The Department of Health in New Zealand act the part of the Devil's advocate in a brochure (1922) on "The Health of Children." They demur to the advice, "drink as much milk as possible," pointing out that an undue proportion of food thus taken in a well-to-do dairying country, would give no exercise to jaws, teeth, or salivary glands

During the War, the Royal Society Committee on "The Food Requirements of Man," seeking for safe minimal diets, reported: "The growth vitamin is present in especially large quantity in the fat of milk. It is partly on this account that milk is of such vital importance for the nourishment of children. No child's diet can be considered satisfactory in which milk or milk fat is not present. Every diet for children should contain a fair proportion of fresh milk."

A pamphlet on milk issued by the Children's Section of U.S.A. Bureau of Labour (1918, No. 35) states: "A child's food cannot be curtailed without damage; milk has no substitute in a child's diet. The price of milk must be controlled. All normal children are better for 1½ pints of milk daily. Whole milk to 1½ pints daily should be furnished to every child below 12, if it is to grow normal in height and weight and not have decreased vitality and lowered resistance to disease."

Sherman and Hawley (*J. Biol. Chem.*, August 1922) shewed that optimum calcium storage was with a quart of milk a day. Milk is unique in furnishing more calcium than any other common food, and the full milk calcium should be maintained up to adolescence. The vitamin controlling calcium absorption is associated with, but separate from, fat vitamin A.

If clean milk could be got from clean animals in clean vessels it should keep indefinitely. The Danish milk, where cows are milked by machinery, does keep well. Kept at 40° F. milk should not appreciably alter in forty-eight hours. Cooled milk is best transported in bulk.

An Australian writer speaks of tanks, of 3000 gallons cooled by ice, being transported by rail for eight hours without warming more than 2° F. Milk should be zoned as regards consumption near its sources to avoid much wasteful transport.

In English schools, contracts for milk should stipulate Grade A milk, as defined in the Milk Acts of 1915 and 1922.

The writer has quoted the above opinions, as in complete accord with his own experience of the value of milk during growth.

In commerce milk is fouled. A visit to a neighbouring tea-shop affords demonstration with a glass of milk. If this is held up and viewed from below, the black mass of impurity seen settled on the bottom is decisive.

Detroit, which in 1923 consumed 1·3 pints *per capita* daily, publishes a monthly list of samples taken, with names of suppliers and full result of analysis and bacterial counts. This work is done in English towns, but requires the same publicity to effect material improvement in quality by indirect compulsion.

During 1917, of the samples of milk taken in London, 37 per

cent. were adulterated. Last year (1925) the proportion was only 10 per cent. of 1119 samples examined.

Milk contaminated with micro-organisms forms a suitable culture medium, and consequently its quality deteriorates hour by hour. Sterilization by heat destroys its qualities as milk, but it may be pasteurized by heating up to 140° F., and all micro-organisms of pathological importance destroyed. A few tubercle bacilli are said to escape occasionally, whilst many of its properties are retained.

Growth vitamin, fat soluble A, is partially destroyed, probably at least half of it disappears, some of vitamin B goes, and all the water soluble C. The antiscorbutic vitamin goes, so that infants wholly fed on sterilized milk may develop infantile scurvy. This is obviated by giving small quantities of orange juice. Fresh raw milk is the best form, if tubercle can be excluded, and this may usually be neglected at school ages; and, incidentally, milk proteins have been mentioned as the cheapest protein which can be obtained.

It is not always practicable to get fresh milk in towns. Its price has become so materially increased, that ere long it will have to come under Public Control.

In spite of drawbacks in the use of heat for pasteurizing or even drying milk, they are outweighed by the advantages of storage and transport. Vitamin C in orange juice has been satisfactorily demonstrated as a remedy for any loss in preserved milk. The saving of loss in pasteurized milk, and its better preservation calling for less frequent delivery service, should to some extent reduce the cost of treatment. Boiling of milk reduces its available calcium content seriously. Dried or powdered whole milk is a convenient form if properly made. It has to be used with the same precautions as if pasteurized.

All proprietary forms of milk are dearer than fresh milk, and so called infants' foods which have milk as the basis may be included as expensive. Sanatogen, stated as about 95 per cent. dried milk casein, with added glycerophosphates, has according to a poster of the American Medical Association, about a tenth of the food energy of the fresh milk which could be purchased for the same money.

Except very few children who have digestive difficulties with carbohydrates, and appear unable to tolerate the fat of milk, much experience in large cities suggests that each child below 14 requires at very least a pint of milk daily, and where this is not made up, there must be an extra compensation in fresh vegetables, particularly of the green leafy parts. Many town children are debilitated, become inefficient workers in later life, and merely waste time as far as much educational effort is concerned. During their growing

period they have a deficiency of dietary vitamins which are to be found in fresh milk or vegetables, both of which are scarce among the poorer majority of the population. For older persons, vegetable milk has been suggested, made from soya bean, as used in China and Japan. In Italy, a substitute for cow's milk is sometimes found in milk made from sweet almonds. Sick children tolerate its casein when sometimes that of cow's milk is rejected.

Nutrition.—In any of these estimates of food requirements, whether as amounts of energy needed to be taken in, or from observations of materials used in diet, final judgment of sufficiency depends on the person or animal dieted remaining in normal brisk health.

Standards are therefore required for nutrition norms, from which defect or excess may be measured. The standard may be composite, an aggregate of several signs and symptoms. The physique of a child may vary with its heredity, race, or family, it may be of a short or slim stock, and yet be normal. Again, accompaniments of normality may be wanting. For instance, in one of the earliest school enquiries on "Feeding" (Crowley's Bradford Report, 1907), children of exceptional intelligence only presented 1·7 per cent. with poor nutrition, where those with exceptional dullness shewed 35·6 per cent. with poor nutrition. A poorly nourished child apparently has a brain whose functioning is defective.

Gastpar, in Stuttgardt (*Zeits. f. S.*, 1908. 689), rejected physical measurements for a clinical inspection of the individual. He first classified a group of children by inspection of skin and conjunctiva, into those with normal circulation, and those who were anæmic. These two divisions again could be classified into three groups—the thinnest, normal, and fattest.

His method was somewhat elaborated by Wimmenauer, of Mannheim, who graduated the thin, normal, and fat according to the thickness of the fat layer subcutaneously. In a later paper (*Zeit. f. S.*, 1912. 601) he calls a child well nourished when, in direct (not oblique) light, the intercostal spaces are not obvious. When the spaces below the nipples shew between the ribs, it is only fairly nourished; if they shew deeply, and appear above the nipple level under the great muscles, it is poorly nourished. Girls have to be more strictly judged than boys, as they tend to be fatter. Since the War he has further standardized his work (*Zeit. f. S.*, 1920. 381). He classifies his children by nutrition, N1, N2, N3, also by appearance in regard to circulation and anæmia, A1, A2, A3. They are then grouped. Group I contains those with N1, A1, and N2, A2. They are sufficiently well nourished not to need school feeding. Group II are N1, A3, and N2, A3, or N3, A3. Group III are those marked N3, A2, N3, A3, and all exceptional children with definite disease.

Peiser set out to determine the fat layer of the subcutaneous tissues as thin, normal, or fat. He recommends the raising of a fold of skin parallel to the axis of the body, about the level of the navel and a little to the left. The fold raised free from the fascia by the thumb and index finger of the left hand lightly held, has the thickness of its base measured by a springy wooden calliper gauge. The error of experiment one would think would be enormous.

G. Hille (*Arch. f. Kinderheil.*, 73. 134) finds that different observers measure this within 0·5 mm. He divides under-nourished children into two categories : Undeveloped (*Untervollen*), which are pathological cases, and do not react to school feeding ;

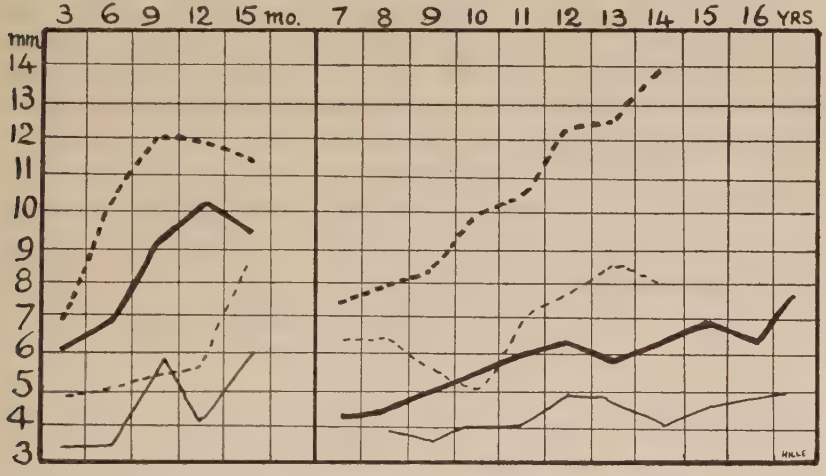


FIG. 25.—THICKNESS OF ABDOMINAL FOLD.

Boys continuous, girls dotted. Normal thick, underfed fine lines.

and Underfed (*Unterspeisten*), who obtain benefit from school meals. The chart is from measurements of 942 children.

In addition to this, the tone of the tissues requires some estimate ; it represents the sum of the nervous reflexes maintaining posture, which again are dependent on circulation and respiration, and these affect the lymphatic drainage, so that a fat anæmic child would appear ill-nourished in its want of tonicity of skin and muscles, its relaxed attention and sluggish circulation.

These children, even in slight degrees, are usually wanting in immunity to the commonest skin organisms—blepharitis, corneal ulcers, adenoids and tonsils, discharging ears, rhinitis, dry scaly patches about the face, or other " breakings out," are common ; bronchitis, colds, clammy blue hands or chilblains are frequent, but without definite disease. They are of poor resistance from ill-nutrition, due to want of exercise and sufficient fresh foods.

A grouping suggested by Dr. Alastair Mackenzie, much used in America under the name of the Dunfermline scale, tabulated children nutritionally as—

1. Excellent, the nutrition of a healthy child of good social standing.
2. Children whose nutrition just falls short of this standard are good.
3. Children requiring supervision are on the border-land of serious impairment.
4. Children requiring medical treatment are those whose nutrition is seriously impaired.

These were what may be termed pre-War clinical methods.

A series of attempts to find empirical formulæ, affording an index of nutrition, has been provided through extensive measurements made in the last decade. Most obvious and probably still the best index is that afforded by weight per centimetre of height. Possibly the use of stem length would improve this value more.

$$\text{The centimetre-gram index (of Quetelet)} = \frac{\text{Weight in kilos} \times 100}{\text{Height in centimetres}}$$

Index of Nutrition.—From measurements of recruits, Bornhardt (1886) gave a formula—

$$\text{Weight in kilos} = \frac{\text{Chest circumference} \times \text{Height}}{240}$$

The more powerful recruits are heavier, the weaker are lighter than the formula gives, but it is accurate enough to predict the weight of an ordinary individual like a recuit within 5 per cent., but more doubtful for children.

K. Oppenheimer, of Munich (*Deutsch. med. Woch.*, 1909. No. 42), gave an index which was one of the first much used.

1. The Nutritive Quotient (Ernahrungs Quotient)

$$\text{E.Q.} = \frac{100 \times \text{Circumference of upper arm}}{\text{Circumference of chest}}$$

He found the E.Q. averaged 29, and when below 26 the physical condition was very bad.

When carefully tested in Mannheim and elsewhere for children, it was unreliable.

The French military surgeon, Pignet, provided what he called the index of robusticity (*Zeit. f. S.*, 1912. 885).

$$\text{I.R.} = \text{Height} - \text{Chest circumference} \times \text{Weight}$$

The greater the value of I.R. the more useless the individual. Up to 10, the individual is first class in every way. To 20 he is

strong, but above 20 proportionately weaker, till at 35 he sets the limit of availability for military service. This method has been approved by many writers, but Guttman, examining these methods on measurements he had made over a dozen years, only approved of Bornhardt as giving concordant results (*Paris Congress Report*, iii. 507).

Another index based on the philosophical idea that it is mathematically unsound to compare a measure in three dimensions, such as weight, with an unidimensional one like length, as in Quetelet's centimetre-gram index, is due to Livi (*Archiv. ital. de Biol.*, 1899. 32. No. 2).

$$\text{Livi's Index} = \frac{100\sqrt[3]{\text{Weight}}}{\text{Height}} = \frac{100\sqrt[3]{\text{W}}}{\text{H}}$$

It is variable with age, and often fails to pick out an under-

TABLE 40.

LONDON REPORT.

Livi's Index ..	1·9	2·0	2·1	2·2	2·3	2·4	2·5	2·6
Nutrition—								
Excellent	—	—	0·7	10·7	50·7	33·2	4·7	—
Normal	—	—	0·4	27·7	52·5	18·7	0·4	0·4
Inferior	0·2	1·3	6·1	35·1	47·2	10·1	—	—

nourished individual. For children at ordinary school ages of 8 to 14, it runs from 2·3 to 2·4.

Investigated by A. G. R. Foulerton (East Sussex Report for 1912), he found it vary from 2·626 boys and 2·622 girls of 3 and 4 years old; through fives, 2·471 boys and 2·498 girls; eights, 2·366 boys and 2·322 girls; elevens, 2·311 boys and 2·286 girls, and for thirteens, 2·272 and 2·280. He found that from 60 to 80 per cent. of residential scholars were above the average index.

Tested on a random sample of cards (London Report, 1910. 128) the index varied from 1·9 to 2·6, but the distribution was that of the curve of errors, and 94 per cent. of cases were included in 2·2 to 2·4. Taking nutritional estimates formed on other grounds, and the index found, the relations are shewn in Table 40 in percentages of each class.

Tuxford (*Public Health*, August 1914) proposed to correct this index for age by using the factor—

$$\frac{\text{Age in years} + 1}{\text{Age in years} + 2}$$

This would give as the formula for Livi's index, corrected by Tuxford—

$$\text{Tuxford's Correction} = \frac{100\sqrt[3]{W}}{H} \times \frac{\text{Age} + 1}{\text{Age} + 2}$$

The index then works out as 2·12 to 2·16. Leipoldt of Cape Town, who used this for a large number of cases, and also tried Pignet's and Oppenheimer's formulæ, finally reverted to nutrition in the "old school routine of 1, 2, 3, and 4."

Another index based on mathematical qualms is that of Rohrer's (*Zurich Corresp. Blatt. Ges. f. Anthropol.*, 1908. 39. 5)—

$$\text{Rohrer's Index} = \frac{100\,W}{H^3}$$

Von Pirquet has an index "Geludisi" or "Peludisi," which is based on sitting height in centimetres being equal to the cube root of ten times the weight in kilos. Put as an equation this is $\frac{\sqrt[3]{10\,W}}{SH} = 1$, and the variations of this give a percentage index of nutrition, as, for instance, 85 or 108, representing the two extremes of ill- and well-nourished condition.

The W/H index gives indications which, applied to the four nutrition groups, gave the following results for the index—

Table 41.

NUTRITION GROUPS. LONDON REPORT, 1910.

Nutritional Estimate.	Good (1).	Normal (2).	Fair (3).	Bad (4).
Boys	253	252	222	204
Girls	284	249	226	210

If the W/H index fails when applied generally, it still gives indications in the right direction, as Pfaundler says, if we imagine a life-size Venus di Medici of 160 cm., she would have a Rohrer index the same as a dwarf of 16 cm. high, which is absurd, but her centimetre-gram value would be 100 times that of the dwarf.

Professor J. Kaup (*Munch. Med. Woch.*, 1921. No. 31) sets out laws of growth, which led him to use the centimetre-gram index, Quetelet's W/H index = Q, divided by the height. This value, Q/H, gives a constant for each age. For instance, the biologically normal young German he takes as height 168 cm., weight 65 kg., and chest circumference 84 cm.

Variations in proportion would be—

KAUP'S TABLE.

Heights	158	163	168	178
Weights	57·5	61·18	65	73
Chest circumferences ..	81·5	82·7	84	86·4

For these measurements Q/H = 2·3.

Kaup's constants for the various ages are—

Age	1	2	3	4	5	6	7	8	9	10
Kaup's constant	1·36	1·72	1·71	1·64	1·59	1·55	1·52	1·56	1·56	1·60
	11	12	13	14	15	16	17	18	. . .	24
	1·60	1·61	1·66	1·68	1·78	1·89	1·96	2·1	. . .	2·3

For the Oxford and Cambridge oarsmen, 1920–5, with average age of twenty-one years, Kaup's constant works out 2·3. This is a good test of its value. For the eighteen-year-olds in the writer's proposed standards it works out : Boys 2·1, girls 2·0. F. A. Schmidt (*Zeit. f. S.*, 1923. 97) worked out for Bonn higher-grade children over weight and over height compared with elementary children—

Age	9	10	11	12	13	14
Kaup's constant	1·63	1·64	1·67	1·65	1·71	1·82

And for girls in Bonn—

Age	6	7	8	9	10	11	12
Kaup's constant	1·55	1·58	1·57	1·59	1·58	1·66	1·69
	13	14	15	16	17	18	
	1·75	1·77	1·87	1·93	1·97	2·02	

Taking children of same height, 137·7 cm., but different weights, he gets for twelve-year-olds—

TABLE 42.

	−5.	−4.	−3.	−2.	−1.	Normal	+1.	+2.	+3.	+4.	+5.
Weights ..	26	27	28	29	30	31	32	33	34	35	36
Q/H	1·37	1·41	1·48	1·52	1·57	1·63	1·69	1·74	1·79	1·85	1·96
	Badly nourished		Poorly nourished		Normal			Well		Over	

Davenport (*Amer. J. of Physic. Anthrop.*, iii. 4. 467) attempts to find an index, and concludes finally, that for young adults the best index is by dividing weight by the square of the stature.

Although the Rohrer index was recommended by the Quaker Speisung in Berlin, and much discussed in Germany, it was soon

condemned as not useful for the individual case, and of only limited use for groups.

All these formulæ fail when applied beyond most limited fields. One of the best given by Tuxford (*School Hygiene*, 1917. 65) affords an index of development. For girls it is—

$$\frac{W}{H} \times \frac{354 \text{ Age in months}}{48} = 1000$$

For boys, take 381 instead of 354 in the numerator and 54 instead of 48 in the denominator. The formula is supposed to shew excess or defect proportionate to its variation from the 1000. Tested on elementary schools it works well, but for girls of the same ages at the North London School it gave the figure 1143.

Weight for Height Standards.—These indices apply to comparisons where one of the data have been fixed, and should only be used in tables for, say, each particular height.

By fixing a weight as normal for each height and taking a definite variation from this as abnormal at a defect of 7 per cent., a useful working first selection is found for ill-nutrition. Such a table is used in America. In Detroit in 1921, weighing 59,000 children and using the Wood scale as standard, 19·4 in every hundred are 10 per cent. or more under weight, and 6·7 in the hundred are 15 per cent. or more below. The same 59,000 children were assessed nutritionally on the Dunfermline scale, and 3·3 in the hundred reported as mal-nourished, class 4. These 3·3 in each hundred (2760) mal-nourished, were then compared by the two methods, and 0·8 in the hundred were 15 per cent. or more under weight, and also visibly mal-nourished, whilst 1660, or 6 in a hundred, were 15 per cent. below and not visibly ill-nourished.

Again, 891, or 3·2 per hundred, were visibly mal-nourished, but were not 15 per cent. under weight.

Whilst the scales pick out under weight, further inspection is necessary to determine the nutrition, and those apparently mal-nourished, even if not under weight, should be very carefully scrutinized. Whilst the anthropometric method makes a rough preliminary selection, the clinical examination is also subject to the personal equation, for the inexperienced examiner selects mainly gross and obvious cases, whilst the skilled physician probably notes double the number, and may reach 20 to 30 per cent., whom only observation will determine whether greater improvement will be the result of care.

School Feeding.—Need for feeding had been raised in France by Victor Duruy in 1868, and feeding established in several hundred infant schools. *Cantines scolaires* were normally organized in Paris in 1880. A recent U.S.A. Bulletin, 1921, No. 37, describing the free meals, which are two-thirds of all in French schools, adds,

"The charity atmosphere so prevalent in English schools is entirely lacking." In England, introduction of popular education was followed by the over-pressure agitation of 1884. The alarm of over-pressure gave way to a cry of under-feeding. Charitable people set to work to supply the want. The question was considered in November 1887 by a Special Committee of the Charity Organization Society, which concluded, "that it was undesirable to create any new and special machinery for the purpose, and that in the few individual cases in which want could be adequately met by gifts of food, the better plan would be to arrange the matter privately."

The first paper on School Hygiene purchased by the writer was a Report in 1891 of a Special Committee of the C.O.S. Society on the best means of dealing with school children alleged to be in want of food. It was doctrines in this Report which reiterated the above conclusion, compared with actualities he was seeing daily, that determined him to push for public activity everywhere, to help children requiring it, instead of passing them over unaided. The "few individual cases" were known to be about a tenth of all, and, before the War, about half this number were being fed in English elementary schools.

Various Committees and Commissions, aftermath of the feeling of national deterioration resulting from the Boer War, are reported between 1902–5, and made references to ill-nutrition and feeding. Unofficial, but powerful, was the propaganda of Sir Lauder Brunton with his Association for Promoting Physical Welfare and Improvement, which indirectly brought about a medical department in the Board of Education.

In 1906 the Foreign Office collected and published information as to school feeding abroad and in America. There seemed to be little in Germany and least in America. The same year saw a permissive Act, the Elementary Education (Provision of Meals Act) in 1906 enabling education authorities to open canteens at a cost not exceeding a halfpenny rate. The authority had to charge the parent for every meal. This flaw has persisted. The teachers strangely got themselves exempt from all lot or part in this work, which should be mainly educational.

This work can be traced in its growth in Annual Medical Reports of the Board of Education. At first, halting and indefinite, by 1912 the high degree of malnutrition in the schools is made evident. The Board are strongly of opinion that where the work is regarded merely in the nature of temporary relief to be administered as cheaply as possible, only in cases of extreme poverty, the benefits derived are bound to be insignificant and transitory.

Before the War a clear doctrine of malnutrition and necessity of widespread feeding, not on a poverty basis, is definitely set

forward. This, the best bit of work which the Medical Department of the Board of Education has given us, probably led to the Education (Provision of Meals) Act, 1914, which passed its third reading on the fateful 4th of August, and became law three days later.

This Act repeals the ½d. rate limit, legalizes provision of meals on any day, and abolishes need for consent of the Board of Education to the provision.

There was no difficulty about feeding in Scotland till 1921, when an Act (the Poor Law Emergency Provisions Act) muddled both Parish Councils and Education Authorities as to who should feed children. Fortunately, the Scottish Board of Health and Scottish Education Department cleared it up by Memoranda, explaining how co-operation was to be effected.

Provision of meals for children in elementary schools is empowered by the Education Act, 1921, 82 to 85, 83 (i): "There shall be charged to the parent . . . such an amount as may be determined by the Authority," and they can recover it as a civil debt. The Regulations provide, V. 23 (i): "The children admitted to the meals must be properly selected." (What does this mean ?) (iii) "Arrangements must be made for recording the effect of the meals on the physical and mental condition of the children." (iv): "Provision must be made for associating the School Medical Service with the planning and administration of the arrangements."

Some of the feeding done up to War-time was shocking, children's meals being provided by contracting caterers at low prices and yet having to make their own profits. Feeding conditions, too, were grossly unhygienic in London, often disgusting, and manners barbaric. These conditions are steadily changing for the better.

Germany then had little school feeding. The subject of nutrition and school feeding only finds five pages out of 750 pages of Selter's work ; the biggest text-book on School Hygiene in Germany, published in 1914. Any feeding given was partly private, and 28 per cent. purely municipal. About 62 per cent. was given in the school-rooms.

Post-War Feeding.—Helene Simon, a year or two before, had brought up the subject in *Schul und Brot* which was widely discussed, and the feeding in English schools cited. Since then, Germany has given the best example of school meals, in the American work of the Friends' Mission, feeding German children in 1920–22. In the summer of 1919 a small group of Quakers went to Berlin. H. Hoover proposed feeding children in the Autumn, and by February 1920 started. By June 600,000 were fed daily. Expectant and nursing mothers and all ill-nourished young people below 18 were included. Germany was arranged into nine districts, and in March 1922, over 2200 kitchens gave 650,000 meals daily, or 15,445,770 in the month, equal to the annual number in English

schools at the outbreak of the War. By the end of August 1922, the Quakers left the work to be carried on by the inhabitants. The only ground of admission or rejection was medical inspection. They issued a practical set of instructions for the examining doctors, which recommended as three useful methods of assessing nutrition, Wimmenauer's, Pirquet's, and Peiser's methods.

In reckoning requirements for feeding, they took the average individual as a ten-year-old child of 28 kilos, needing 58 per cent. of adult food or 1740 Calories daily. This was distributed as 42·5 gm. proteids = 170 Calories ; 37·3 gm. fats = 425 Calories ; and 276·2 gm. carbohydrates = 1140 Calories.

The meal at first was intended as chief meal, but soon altered to a smaller meal of high caloric value. A sweet roll of 244 Calories with cocoa (330) or rice dishes with milk or vegetables (330) or bean soup (348), so that a daily average over 600 Calories was given.

The children were—

Class I	Feeding unnecessary.
Class II	Desirable.
Class III	Necessary.
Class IV	Good feeding for a long time absolutely indispensable.

Many in Class IV could hardly digest meals, and only gained very slowly.

Although there was little school feeding in America before the War, in 1914 the secretary of the New York School Lunch Committee wrote (*The Modern Hospital*, November 1914) : " The genesis of the School Lunch movement is to be found in the destitution of the people. Absence of the necessaries of life results in a class of badly nourished children. In England, with its tradition of peasant exploitation, the social renaissance faced a situation so acute that in the beginning a policy was formulated which provided for the free feeding of necessitous children.

" The physical welfare of the child to-day is an index of the sturdiness of the state of the future. Apart from this, the large sums of money spent for education are largely wasted on these mal-nourished children.

" It was estimated in the year before the War that a million dollars of educational funds failed to bring about the results which were reasonably to be expected had the money been spent on physically normal children. Industry in the past has in many cases destroyed the home—wives have to work; children are growing up in neglect ; working mothers have no time to cook dinners. The school meal comes to their relief, and the school meal has other purposes than mere food provision ; it must not be under-estimated in its social

and educational aspects." The table manners of civilized life are a public asset.

The New York Committee for providing School Lunches gives no food free. The Charity Society provides the mother with money to pay, but food is sold at cost price and the Society pays administrative and overhead expenses. There emerges two valuable points, the economy of the central kitchen, and the opportunity for medical inspection of food handlers.

In an enquiry in North London, A. H. Gerrard (*Lancet*, February 13, 1909) investigated 1000 dinners and 1000 breakfasts. Only 2 per cent. had milk with breakfast, and scarcely 3 per cent. cereals. Oatmeal porridge with milk, an ideal food for children, was scarcely known. At dinner 84 per cent. had animal proteid ; if cheese be excluded from this, a further 4 per cent. had cheese.

Margaret McMillan writes of the " system of investigation instituted on charity organization lines calculated to deter all self-respecting parents from making an application on behalf of their children," and she notes well that the famishing are not as a rule very hungry.

The C.O.S. methods adopted in London have much discounted the value of school feeding there, as a means of physical development of children. Well-fed public school boys are ravenous, whilst the starving will often turn away from a good dinner. A hunger dyspepsia is a definite entity. Gephart's boys, on meals of 4350 Calories, were found to be buying an extra 650 Calories chiefly as chocolate.

The central kitchen means economy, and the school lunch as a co-operative measure, apart from any charity, is a success. It offers opportunities for personal hygiene, and means hot water, separate towels, and a soap-holder. Decency is worth while in handling and serving of food, apart from waste, which is enormous, through improper storage and distribution. Drinking fountains, also, should be provided and the school lunch is a factor in controlling malnutrition. In America malnutrition has almost become a stunt since the War, and much is made of feeding and instruction.

Kansas City, in 1919, had a study of malnutrition, in which the lowest school, standing fifty-fifth on the list at the end of March, by intensive health service and nutritional treatment for nine and a half weeks was raised to third place by September (Dr. Maud Brown, *J.A.M.A.*, July 3, 1920).

In 1919, arising out of observations on leavers at the age of 14 applying for work certificates in Chicago, 53 per cent. of whom were 7 per cent. below standard—height $57\frac{1}{5}$ in. (145 cm.) and weight 80 lb. (36·3 kilos)—it was soon found that the problem of malnutrition could be better handled in the schools backed by authority.

Putting the responsibility for their own gains on the elder children, a psychical element of auto-suggestion is introduced, which appears to accentuate the good effects.

In San Francisco, 33 per cent. were stated in 1921 to be under weight, and 21 per cent. beyond the 7 per cent. limit. In Detroit there were 128 nutrition classes, with improved health to two-thirds of those attending. The powers of such classes as weight producers are merely incidental to others tending to social improvement and home hygiene. The improvement in health is taken to result from hygienic education, more than any school feeding.

Malnutrition is an individual, not a group, problem. It is not the mere accompaniment of any numerical index, but heart disease, thyroid over-action, want of sleep, over-activity, even nervous excitability, are common accompaniments, and pathologically make it up. It may be an early symptom due to chronic effects in phthisis, pyelitis, appendicitis, sinusitis, chronic tonsillar, and other inflammatory conditions of the naso-pharynx. It is also a sign of such organic conditions as deviated septum, intestinal adhesions, and reflex disturbances shewn by cardiospasm or anaphylaxis due to protein sensitization.

It may likewise be a symptom of secondary toxæmias from focal infections, gastric or intestinal indigestion, over fatigue, bad air, or lack of sunshine.

The effects of feeding before and after the War may be judged from charts for Apolda, and the results of good food secured by rationing as shewn in the Govan measurements charted. The Apolda results were obtained by Dr. Jaenicke in 1902–7, and again in 1921 (*Off. Gesund*, 1921. 181). The Govan results are for 1907–13 and the War years 1914–19, and shew the benefit from better distribution raising the average feeding. It is to be remembered that Govan is intensely industrial, whereas the Saxony town is agricultural and country (Fig. 26).

There is no doubt of the British alleviation of pre-War misery. In post-War times (1925), with a million people out of work, the "dole" is securing living conditions for the poorest children, such as were impossible under economic conditions ten years earlier.

Dr. Badger, in Wolverhampton, discussing malnutrition, arrived at the conclusion: "When, however, we have accounted for all the malnutrition attributable to obvious and known causes, we still have to deal with a large number of mal-nourished children who are not short of food, who live in comfortable circumstances, and in whom no obvious cause of malnutrition exists."

Probably these are the children mentioned in an early L.C.C. Report, as the children of the snobbish lower-middle class, not permitted to play in the streets, unexercised and over-fed, lacking

in stimulus to circulation of lymph and blood, whose tissues are choked by their own waste products.

Nutrition Classes and Clinics.—Dr. W. R. P. Emerson and his fellow-workers established nutritional clinics in New York, where in a few months standards were formulated and the subject surveyed in all aspects. They point out, as the writer had previously done, that standards are lamentably wanting. The averages of debased figures being generally accepted instead of optimal measurements. Emerson states that malnutrition exists to a greater degree among the rich than among the poor, and that it is a definite clinical entity with characteristic history and definite signs. The clinical

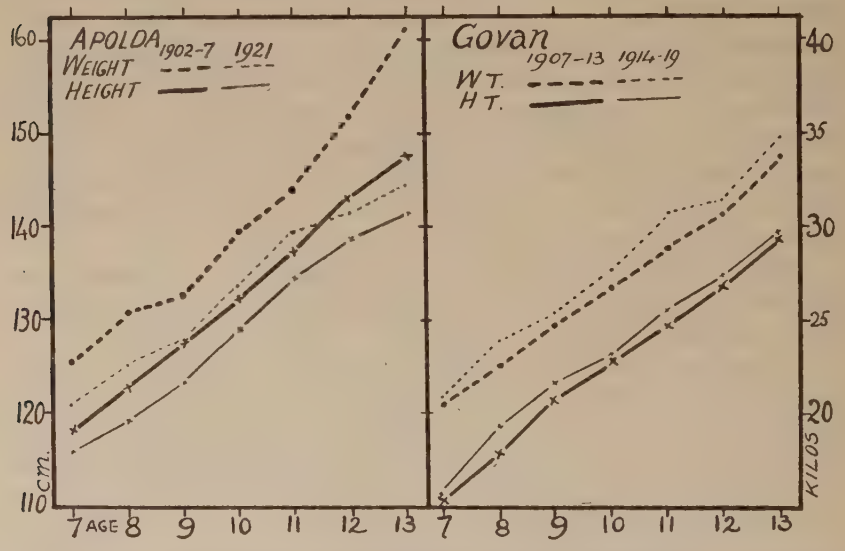


FIG. 26.—WAR EFFECTS ON PHYSIQUE OF SCOTTISH AND GERMAN BOYS.

picture of malnutrition is that it " comes on " after a certain illness or as result of over-fatigue or faulty food or health habits. The child becomes irritable, tires easily, lacks physical and mental control, and exhibits other indications of nervous disturbance. Among physical signs, besides lowered weight to height ratio, are lines under the eyes, anxious expression, pallor, mouth breathing, and other signs of naso-pharyngeal obstruction; the anterior cervical glands are apt to be enlarged, muscles flabby when tested by feeling the upper arm; there may be fatigue posture, prominent abdomen and pronated or flat feet, round shoulders, lateral curvature, flat chest, and rigid spine. It is also the picture of the nervous, so-called infantile neurasthenic child; the condition sometimes called " over-pressure."

By fatigue posture is meant an appearance similar to the senile

stoop due to weak muscles. Being due in the majority of cases to physical defects, improper foods, over-fatigue, and habits and errors of life, makes its correction partly medical and largely educational.

In planning work there must be no loophole for failure ; also, publicity pays. There are five essentials for the growing child : (1) The removal of physical defects. (2) Inducing the child to feed sufficiently at proper times. (3) Adequate ventilation always. (4) Prevention of fatigue. (5) Good home-control as regards food and health.

Simple causes are found to explain some of the worst cases, such as rapid eating, closed bedroom windows, tea and coffee, late hours, poor hygiene, and over-pressure at school.

The definitely under-nourished child is commoner in secondary than in primary schools in London, but this may be an age relationship to adolescence. Figures for 1922 were : 5·8 per cent. boys and 5·2 per cent. girls in primary schools markedly under-nourished, and 7·2 per cent. boys and 13·7 per cent. girls in secondary schools. These are in confirmation of Emerson's statement that it is commoner in better social classes.

The child who is chronically 7 per cent. under weight is practically one year retarded ; 18 per cent. were found so at Emerson's clinics. Mal-nourished are about one-third of all. The " specials " were among exceptionally bright children.

The Working of Nutrition Classes.—The American classes are in rooms with two rows of ten seats. The child gaining most is given a gold star, and placed at the head of the class, the others in order of weight. Charts of their weight are placed opposite each child, weight is charted weekly, and a diet list kept for two days each week, until food habits are shewn. A complete physical examination is made according to a schedule, and defects corrected until they are " free to gain."

Much importance is attached to records and to keeping to the main purpose. The schedule is filled in by underlining conditions found, this being taken as a guarantee that observation has been made.

Rest Periods.—Half an hour, forenoon and afternoon, is spent lying on the floor wrapped in a blanket. The worst postural conditions are seen, or appear to be, in superior mental groups.

Feeding consists of a small lunch of 250 Calories to certain groups in mid-forenoon, dinner of 1200 Calories to others in the middle of the day. Children gain faster on less food taken in small amounts five times a day than with larger amounts taken in three meals. Home visits are also made and hints given as to hygiene.

Children shewing all signs of malnutrition are found, who have

at least a sufficiently good diet to have enabled other members of the family to grow in apparently normal fashion, shewing some other factor of ill-nutrition than diet.

The most important defect noted was naso-pharyngeal obstruction. Question of operation was often sealed by the child's failure to gain weight, so that the class method is a valuable aid in the diagnosis of toxicity. The class method, without developing self-consciousness, also appeals to the imagination of the child. It is sound pedagogy. There is no evidence that malnutrition, if untreated, tends to correct itself. Much of the nation's physically unfit seems supplied by this section of malnutrition among children in the schools.

Salvaging can be done at pre-school age or in younger years of school life. In school years time for fundamental work in establishing robust constitutions is almost past. The time when the enamel of the teeth is being formed is critical, but dieting the mother is then required. There does not appear to be sufficient use of protective foods, such as milk and green vegetables.

If 10 per cent. under weight is taken, it omits many ill-nourished; 7 per cent., which is equal to one year's growth was found to be the best division; 20 per cent. over weight is obesity. A certain number of children in the central zone of weight-height are stunted; they have under weight and under height. They usually react well in growth. Twenty to 40 per cent. of American children are habitually under weight, and present signs of malnutrition. All tables now in use are vitiated as Standards by including these children.

The over-weight child may also be pathological. Many big, pulpy children with deficient exercise were over weight, but it seemed chiefly water. Veeder (*J.A.M.A.*, 1924. ii. 486), studying over-weight boys of a good public school, thought the body type or habitus played a large part. He took those as over weight who were 20 per cent. above the tabulated averages. He assessed them in two groups, one or two were gonadal, or Frolich's, type. The others had excess of fat about the pelvic girdle, of the type thought to be pituitary or endocrine in some way. Heredity seemed to play no part. Others, his second group, presented a general diffuse adiposity which was also present in one or both parents, and which he associated with hereditary disposition and perhaps also over-feeding.

If seasonal variation is taken into account, a fixed percentage above or below a standard like Holt's is not sufficient (*Am. J. Child. Diseases*, 1925. 328).

H. K. Faber, from considerations of the variability, has shewn that the percentages must vary with age and sex, as the variability increases enormously with age, and is very much greater with girls.

He has calculated the percentages which should exclude 10 per cent. of over weight and 10 per cent. with under weight.

His figures, smoothed, give deviation percentages allowable for each age, as in Table 43.

The Pirquet or Nem System of Dieting.—Pirquet, in Vienna, worked out a rationing system which visualized the unit of food as a quantity of milk, the ideal and complete food. His system is simple and concrete; his Standard, the nutritive or metabolic value of 1 c.c. of milk, represents about 667 small calories. The unit thus defined he calls a Nem, this being formed from initials of Nahrungs-Einheit-Menge, or content of the nutrition unit.

A small cupful of milk or hectonem is 100 c.c., or 66 Calories value.

He has prepared extensive tables of food values expressed in Nem. For instance, a gram of sugar is six times the food value

Table 43.

Age	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Boys—										
Under weight ..	7	7	7	8	8	8	9	9	9	9
Over weight ..	9	9	9	10	10	11	12	12	13	13
Girls—										
Under weight ..	7	7	7	8	9	9	10	10	10	10
Over weight ..	9	10	11	12	13	14	15	16	17	17

of milk; he calls this 6 Nem. Cow's milk is equal to human milk, but the infant does better on it diluted with equal parts of water. If to 100 gm. of water 17 gm. of sugar are added, this solution with equal parts of milk is equal in Nems to 100 c.c. of milk.

Fat he regarded during the War as a luxury, and replaced it wholly by carbohydrate of equal Nem value. Protein should be up to 20 per cent. of the diet, with a minimum of 10 per cent. Nems of proteid.

To calculate energy requirement of the individual, he takes each square centimetre of intestinal area as supplied by 1 Nem daily. Its area works out as $S H^2$, or the square of the stem-length in centimetres. This nourishment area—Ernahrungsflache—is the basis of his calculations for daily diet.

The maximum diet which could be absorbed would, however, overtax the digestive system, and Pirquet estimated the basal metabolism at three-tenths of this. The growing child, he says, needs another tenth for growth, a tenth to maintain fat reserves, and a tenth for ordinary activity. If very active, an extra

tenth, making a child's requirements seven-tenths of the maximum. A person of 75 cm. sitting height, if lying in bed, would thus require

$$\tfrac{3}{10} \times (75)^2 = 1687{\cdot}5 \text{ Nem}$$

The general system on these lines, worked in Vienna. Feeding on the largest scale acted as a great machine, smoothly and well, but it is unlikely to be adopted elsewhere. It is really a rule-of-thumb method, founded on scientific ideas; stem-length being a better relative body measure than the total height, and the Nem a convenient quantity.

Jellinegg (*Wien Klin. Woch.*, December 15, 1921) found that in young children the intestine varied from eight to fifteen times the sitting height. When applied to San Francisco children, as Faber describes (*J.A.M.A.*, December 3, 1921. 1837), the Pirquet formula gave enormous discrepancies in individual cases when compared with the results of weight-height index. Hamburger and Jellinegg found its error about 40 per cent., and in practice it does not appear any better than the Rohrer index, although at first sight more reasonable.

When brought to the test of use with controls, these indices fail. Taliafero Clark and others have worked out a comparison of three methods of determining nutritive condition by indices. (*Public Health Reports, U.S.A.*, 1923. 1239.) Over 500 children were selected by clinical examination as of good or excellent nutrition. They had no noteworthy physical defects, and were native whites of the third generation. By the Wood height-weight age standards, 20 per cent. were 10 per cent. or more below weight; according to Dreyer's standard, 13 per cent. were 10 per cent. or more below weight; according to Pirquet's formula, 17 per cent. were under weight, with Peludisi index 94 or less.

Thus, out of 506 children normal and healthy as far as could be clinically judged, 210 were significantly under weight by one or other standard, and in fifteen cases all three methods gave the child under weight.

These were selected as the best specimens of health that could be found amongst school children, but one-fifth of them were under weight by the standard most commonly used in the United States.

The Board of Education Regulations, on which half the cost depends, wisely requires that the feeding arrangements in English schools shall be co-ordinated with the School Medical Service. The doctor has the duty of supervising dietaries and should examine them from time to time, both as served and in the laboratory. Dinner should contain the greater portion, say probably two-thirds, of the daily protein requirement, and the meal a value not less than 700 Calories. Particular attention should be paid to quality of materials.

Accommodation should be made so that a queue of children may not be seen standing in drenching rain, or exposed to biting east wind. There should be provision for washing the hands at least, either in school or in the neighbourhood of the dining-room, and in Winter this necessarily means hot water. No other arrangement can be regarded as adequate. Soap and sufficient towels are required beyond the usual wet roller towel for a score of children. This probably raises the whole matter of the minimum conditions of decency in living, and many schools in this country have no washing provision of any sort, or even water for drinking.

The Director of the New York Association for Improving the Condition of the Poor says well : " From a health point of view it is more important to teach the school children to wash their hands before eating than it is to solve the problem of sewage disposal."

Meals should have drinks provided with them, with separate drinking vessels. This country should have passed the barbarism of common drinking pots long ago. Suggestions of a Medical Officer printed by the Board, that there should be due decorum in the ritual of the meal and no hurry, and that no one should be permitted to leave the table till all are finished, are indirectly matters of fundamental hygienic importance.

In selection of children for feeding, all children noted at medical inspection as Nutrition 3 or 4, subnormal, should be reviewed. To judge from published statistics, i.e. 10 to 20 cases of lowest class, Nutrition 4, in a term's inspections in London, this last category needs revision. One knows that it is nonsense. These children we would suspect as more in need of being seen in hospital than in school, and probably most of such cases were not included from being absentees.

Apart from medical inspections, children not in inspected age groups are rarely sent forward for feeding. In this matter Care Committees are incompetent as a public protection.

Monthly recording of weights of all doubtful children is the only safe prophylaxis. Effects of school feeding could then be followed by rates of change of children both before and after attendance. It is only safe insurance against wasteful expenditure of public money, although no proper feeding of a child is ever likely to be wasteful. In the pre-school child when debilitated, anorexia or refusal of food is the chief bad habit to be reformed.

Charts, such as those kept at the Rachael McMillan school, are easily made, and as shewn by the American workers, of enormous aid to older children themselves (Fig. 159).

The idea is following growth of every child in the elementary school by means of its height and weight card charted monthly ; elimination of all ideas of charity, and regular feeding of every child who will take meals ; abolition of the wasteful, but statutory

process, involving spending double the amount to recover a penny of the cost of feeding.

Higher Education.—So far the elementary school has been mainly in mind, but secondary schools present many cases where feeding is requisite for good work.

Gephart's observations were made at Concord, where all food consumed was totalled, and also all food bought separately by boys at the "tuck shop." He found that 360 boys in this American secondary school averaged 5000 Calories daily, and all but the oldest group took over 100 Calories per kilo weight daily. His figures are shewn below.

Blunt and Bauer, in studying a group of college women of nervous type, and under weight by insurance standards, found basal metabolism normal, but the food averaging 1830 Calories

TABLE 44.

GEPHART. BOYS' DIETS.

School.	Average Age in Years.	Average Weight in Kilos.	Average Calories per Kilo.			Total Daily Calories.
			School.	"Tuck Shop."	Total.	
Lower	13·5	43·6	98	15	113	4949
Middle	14·5	50·8	88	13	101	5126
Upper	16·1	60·6	71	11	82	4997

or 37·3 Calories per kilo weight. Nearly all were about 500 Calories below requirements.

Graham Lusk (*Physiol. Rev.*, i. 523. 1921) has shewn how insufficient diet means decrease in efficiency, muscular activities become restricted, desire for roaming and sport is lost, and initiative goes, the mind becoming depressed and movement listless. Similar results in varying degrees occur with young teachers living mainly on tea and toast. Insufficient diet has always to be suspected in young, highly educated women of lean and nervous types. Many children holding scholarships in secondary schools fall short in attainment from poor feeding at home. Most need 50 per cent. more than an adult.

The growth of general school feeding and its further extension is based on sound economic principles, and it should afford an educational demonstration in cleanliness, else all our cleansing schemes are vanity. It is capable of being used, as an instrument leading to healthier living and sound physique, beyond any other means at the disposal of the school.

CHAPTER VI

DENTAL HYGIENE

Dental care is such a universal requirement in school children that it is now recognized as a public duty. The relation of dental condition to health must be carefully considered by any worker in School Hygiene. Dental treatment by operative measures is a matter of expert detail which lies beyond the ordinary field of school hygiene. Oral hygiene, the prevention of sepsis, and dental toileting is a matter for school instruction and treatment.

The teeth develop below the surface in the alveoli of the jaws. The general plan of a tooth is a solidly constructed crown which appears above the gums, joined to one or more roots or fangs by which the tooth is firmly fixed on the structures covering the alveolus. The gum is the hard elastic mat which covers the alveolar process. Its fibres are closely interwoven with the fibres of the periosteum, and thus the soft parts are fixed and immobile. The little triangular pad of gum between the necks is called the interdental papilla. It prevents food being forced between the teeth. In health the free border of the gum thins to a knife-edge close to the enamel, to which it is not actually attached, so that there is a potential cavity in which septic material or tartar may deposit, or into which food particles or bacteria may get and gradually form pockets, starting-points for pyorrhœa.

Septic gingivitis, or inflammation about the teeth, should always be looked for, and any looseness of the teeth tested, as pyorrhœa is one of the commonest sources of chronic troubles among scholarship candidates and teachers. Wherever this is suspected the case should be referred for expert dental examination. Slight gingivitis appears in about half the children seen, due to neglect of dental care.

The greater part of the tooth is made up of dentine, a hard, ivory-like material, surrounding the central pulp cavity. This cavity is filled by the pulp made up of connective tissue cells with nerves, blood-vessels, and lymphatics, which, entering it through the root canal openings, maintain the nutrition of the tooth.

Over the dentine of the crown is a covering of enamel, thickest on the cusps, where pressure comes. It is the hardest structure in the body. It extends on the neck of the tooth to just below the

alveolar edge, and is mostly overlapped a little by the cementum which covers the neck and roots.

The milk teeth begin to be formed about the seventh month of fœtal life, and as the enamel cap is an epidermal structure, its formation is easily altered, as is that of any epidermal tissue by slight changes in metabolism. The difference is, that whilst change in skin or hair is temporary, slight changes in the enamel are fixed and durable, and only recovered with difficulty. The order of formation of the enamel can be followed sufficiently in Fig. 28.

The eruption of the teeth takes place in regular stages. There may be considerable variations in the actual times of eruption, but by two years and a half a normal child should have twenty teeth.

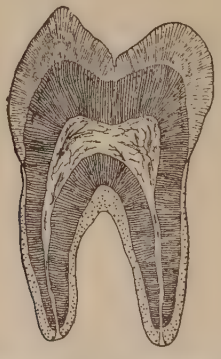


FIG. 27.—DIAGRAMMATIC SECTION OF A MOLAR, TO SHEW THE ENAMEL COVERING OF THE CROWN, THE DENTINE, WITH THE PULP CAVITY AND NUTRIENT VESSELS, AND THE CEMENTUM COVERING THE ROOTS.

Occasionally an upper incisor is found erupted at birth, but the time of the first tooth appearing is between the fifth and ninth month, and most usually at the beginning of the seventh. Delay suggests some general retardation, and is common in feeble-minded children. The four central incisors are followed by the lateral incisors from the seventh to ninth month, the first molars soon after the first birthday, the bicuspids about the seventeenth month and the second molars about the end of the second year.

The mouth may easily become deformed at early ages. The effects of nasal obstructions are notorious, and may prevent clear speech by causing sigmatism from malocclusion. This deformity is probably a great factor in caries and sepsis. Harries, studying the children free from congenital syphilis or rickets, differentiated a type with thickened upper lip, extensive caries of upper incisors, and sometimes protrusion, which he grouped as comforter caries (*Lancet*, 1911. ii). Thumb sucking and various habits, or even

decubitus, may have a like effect. In all this period calcium is wanted for growth. The mother often suffers in bones or in teeth, and if the child does not have enough calcium it also suffers. Milk and vitamins are therefore necessary in the pre-natal and also in the corresponding post-natal periods if the suckling's teeth are to be well formed.

Whilst the temporary set are functional the permanent teeth are coming into existence below or behind. The six-year-old molars,

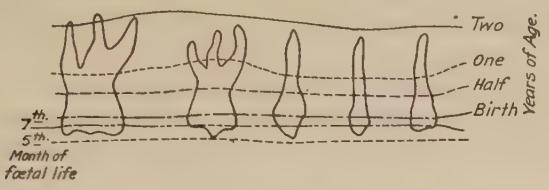


FIG. 28.—TIMES OF CALCIFICATION OF TEMPORARY DENTITION.

which hold the key positions of the denture, have the tip of the crown laid down in the eighth month of fœtal life. The enamel is calcified about the fifth year, and they erupt just behind the temporary molars between the fifth and seventh years, a little earlier in girls. They have come through in a quarter of the children of $5\frac{1}{2}$ years, in half of them by the sixth birthday, and in three-quarters by $6\frac{1}{2}$ years.

Upper molars generally appear about three months later than

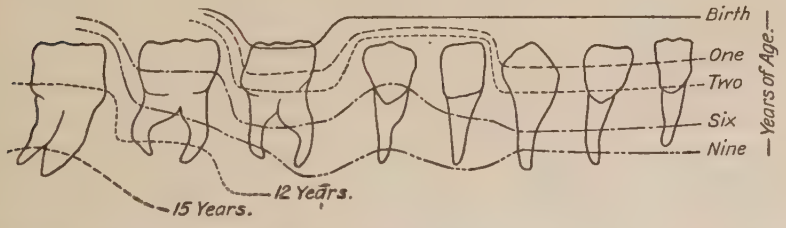


FIG. 29.—PERIODS OF COMMENCING CALCIFICATION OF PERMANENT TEETH.

the lower. Much delay in the eruption of the molars may be due to rickets or mere want of development and poor nutrition.

The time of eruption of the other permanent teeth differs in boys and girls. The Report of the U.S. Bureau of Education for 1904. i. 38 has an exhaustive study of the statistics of growth by Boas and Wissler. It shews the age and variability of eruption.

In the case of the incisors the lower ones are the earliest, whereas the reverse is the case with the canines and molars. Table 45 shews how indefinite can be the eruption of particular teeth.

James and Pitts give figures for 4850 children in the *Proc. Roy.*

Soc. Med., vol. v. 1912, but without distinguishing the sex. At school ages the girl has generally a tooth more than a boy of equal age. The recent enquiry of a Medical Research Committee agrees with these data (Special Report, No. 97).

Care of the temporary teeth is important in regard to the health of the permanent ones and their preservation, but also for the child's own health, so that it may learn to chew its food, instead of acquiring the habit of bolting through having tender teeth.

For the school doctor, care of the teeth almost begins with the six-year-old molars. It should be carried on in pre-school days by dental nurses or hygienists.

In filling up the schedule of routine medical inspection the school doctor is asked to record under teeth, " The general condition and cleanliness of temporary and permanent teeth, and amount of

TABLE 45.

Observation.	Girls' Age.	Boys' Age.
Inner incisors	7·0 ± 1·6	7·5 ± 1·4
Outer incisors	8·9 ± 2·1	9·5 ± 2·1
Bicuspids	9·0 ± 2·8	9·8 ± 1·6
Canines	11·3 ± 1·0	11·2 ± 1·4
Second molars	12·8 ± 1·6	13·2 ± 2·0
Wisdom	22·0 ± 1·8	19·3 ± 2·1

decay. Exceptional features, such as Hutchinsonian teeth, should be noted. Oral sepsis."

The rapidity with which these six-year-old molar teeth are destroyed is due greatly to the idea that they are temporary teeth. They are the largest teeth and behind the milk teeth, and most parents are astonished when told that they are permanent teeth which will not be replaced. They can be distinguished when other teeth are missing, because those of the temporary dentition are whiter, more pearly and translucent in the enamel, and have constricted necks and splayed-out roots compared with the permanent. The temporary canines can be distinguished by the sharply marked facet on the cusp.

Caries is the essential disease apart from which other mouth defects are of less public importance. It is one of those disorders, like myopia, of which a great deal is known, but any single cause, if there is such, is quite unknown. There is scarcely any doubt that caries has increased in prevalence during the past century. Further, it is not widely prevalent in mankind living an animal life. The Maori, the Australian bushman, or the Kaffir are all free till they eat the food of civilization. Diet has to do with it, although diet is not alone the cause.

The diet which is universally deemed worst for the teeth is carbohydrate material, which easily accumulates in fissures between the cusps, in notches, or holes, in association with bacteria, where it ferments, producing lactic acid, and this attacks and decalcifies the enamel; the inorganic material being removed, the bacteria soon destroy the organic basis of the tooth structure. Conditions, therefore, which destroy the even smoothness of the dental surface contribute to caries. But these are not enough, else a dead tooth could not remain for years unharmed. There must be some active process in teeth themselves which, as it were, sensitize them to caries. Probably it is the calcium demand for growth. It would be a legitimate enquiry as to variation of caries with season. The calcium tide in the blood is raised in Autumn and exhausted by the growth demands of the Spring. Caries ought to be advancing more rapidly in the March–June period of the year. The enquiry would be well worth while.

Whilst the temporary teeth may be misshapen, they are usually smoothly and evenly formed, and the permanent ones shew many defects. The preventive part of school work should therefore include not only children, but their parents. Instruction as to pre-natal care and immediate post-natal nutrition is important. It is doubtful whether a toothless mouth is not better left alone, the scrubbing and rinsing with the fingers are more likely to do harm than good, to scratch mucous membrances and inoculate cocci, rather than to sterilize the mouth.

A certain amount of roughage and even tough crusts and rusks are useful to develop young jaws, and with proper pre-school care the nurse should inspect teeth from time to time, and watch for the very beginnings of trouble. Here, above all, can money be well spent with the certainty of a rich return in good health. Calcium in the food, notably fresh milk, and the calcium fixing exposure to free sunshine are the main available agents of health and obvious preventive measures.

Hypoplasia of the enamel is recognized as one of the conditions which conduce to caries.

(1) In its commonest form J. L. Dick describes this as an even degree of thinning all over, or

(2) Thinning in even horizontal furrows, like the furrows on nails after illness, or

(3) Pits and holes in the enamel in horizontal strata.

These describe the conditions as one visualizes them on the incisors. These results may follow any conditions affecting the metabolism of epidermic structures at the time the enamel was being laid down. Similar changes are seen in congenital cataract, where in the fibres of the lenses some have been laid down in such

a defective way that they present small opaque striæ in the lens in later life.

As seen in the school child, dental defects originate mostly after birth. The tips of the six-year-old molars are just forming in the two or three weeks before birth, so that the changes noted in enamel on the permanent teeth are post-natal in origin. The crowns of the milk teeth are generally smooth, polished and translucent and pearly. They do not usually shew post-natal effects. Hypoplastic effects of malnutrition shew on the permanent teeth and may effect nearly the whole of the crowns of the six-year-old molars, on the coronal half of the central incisors, and a little less on lateral incisors, and perhaps tips of the canines. Want of calcium, phosphorus, and vitamin protective foods may be taken as important contributory factors. Fixation of calcium is an important item in enamel formation.

Dr. Cook attempted to correlate hardness of water in districts with proportions having four or more carious teeth, and found a close relationship. For caries of four teeth, with total hardness, the relation is $r = 0 \cdot 4702 \pm 0 \cdot 05$. For temporary hardness and caries $r = 0 \cdot 491 \pm 0 \cdot 06$. Similar correlations were obtained in relation to infant mortality. The conclusion was, the harder the water and lower the infantile death-rate the better the teeth (*Lancet*, 1914. i. 888).

Toxins of syphilis have little effect on the milk teeth, but the actual congenital syphilis due to spirochætal infection is notorious on its marked dental results on the permanent teeth. The notched incisors which Hutchinson described appear to be rarer than in the last generation. Only two out of nearly 5000 examined by Ainsworth were Hutchinsonian teeth. The general appearance is defective formation. The six-year-old molar, laid down in the period of greatest activity of the spirochætes, may be dome-shaped from defective development. The want of development of the crowns also shews in apparent spacing of the incisors. The upper incisors bear the brunt, and the central part being wanting a small notch appears which is characteristic. It exists early, and has been photographed in the unerupted teeth of a five-year-old child (*J.A.M.A.*, 1923. i. 28).

Microdontism.—Doll teeth, peg teeth, are almost certainly accompanied by other luetic appearances.

In inspecting a child's teeth with the suspicion of syphilis in mind, the absence of the Hutchinson notch is insufficient evidence, if the first molars have not been carefully examined.

There has been a general opinion that the dark-complexioned elements of the population shew superior vitality and greater resistance to disease. Magitot, half a century ago, declared the Alpine elements of the French population to be the best from the

dental point of view. Bolk, of Amsterdam, taking anatomy students in three groups, blonde, dark, and mixed, found that the blonde group had 17·4 per cent. with defective or lost teeth, compared with 11 per cent. in the dark. The six-year-old molars affected or lost in the two groups were, blonde 54·7 and dark 27·0 per cent. (*Zeit. f. S.*, 1913. 46). These observations are confirmed by those at Cambridge, that dark brown or grey eyes were dentally superior to types with blue or light brown eyes (1913).

Caries is the great disease of civilized life. No one can give an explanation of its cause, which is quite free from objections. The teeth are vital organs in this matter. They do not play a passive part. Caries is an active systemic disease. It is contributed to by diet of certain kinds. There is constant and abundant invasion of the oral surfaces by a great variety of putrefactive organisms. Certain common carbohydrate diets of soft, pulpy nature, lodging about the necks of the teeth, afford a good nidus for micro-organisms, with the result that lactic acid fermentation goes on till a concentration is attained which decalcifies the enamel. This is much accelerated if there are already small pockets or pits in the enamel.

Various pastes or powders may be used to aid the tooth-brush in cleansing. Their basis is precipitated chalk, or light carbonate of magnesia, with powdered orris root or other flavouring material. No attritive material like pumice powder is permissible. The Bridgeport dentists advocate the regular use of a mouth wash of lime-water thrice daily to remove the mucin which helps to form plaques.

Many dentists suggest salt and water for regular use. Such a solvent and the friction of the brush on the gums should stimulate the circulation of the gum edges, keep them firm and wholesome, and prevent the development of chronic gingivitis.

A clean mouth is a good beginning, but "a clean tooth never decays," and "clean teeth—good teeth" are only partially true as statements. In some mouths all the brushing and washing will not keep the teeth wholesome, whilst a few remain healthy in spite of the stickiest carbohydrates and sugar.

There are cases especially of first molars where, with improved health, caries is arrested and recalcified dentine appears to form. Many teeth with superficial carious patches are arrested by a dressing of solid silver nitrate. Arrest of caries, whilst common in temporary, is comparatively rare in permanent teeth. Earliest signs of caries require searching out and treatment, otherwise enamel may be gradually worked through to the dentine, widely invading micro-organisms passing down the tubules in it, and violent inflammation of the pulp set up, extending through the root canals to start a dental abscess with great pain. Usually this discharges as a sinus

in the alveolus, a gumboil ; very rarely a sinus forms through the external surface of the cheek.

Focal Sepsis of Dental Origin.—Apart from these open abscesses, there may remain septic foci about dental roots, where there is no acute suppuration, but from which toxins are being sent into the circulation. There may be no acute disease, but the patient may never be well, always fatigued and miserable.

The credit of first insisting on the importance of oral sepsis in general medicine rests with Dr. William Hunter, of London (1900), who urged that many pharyngeal, gastric, and hæmic troubles were caused in this way. His statements about the intensity of scarlatinal angina being proportionate to the amount of dental sepsis made the subject of prime importance in school.

Some years before this, W. M. Fisher, in Dundee (1885), had urged the care of children's teeth, and the School Dentists' Society originated (1898) from the activities of Spokes and Fisk. The first extensive elementary school dental work was Cunningham's in Cambridge. Jessen's work in Strassburg about the same time, arising out of his desire to secure dental prophylaxis for future recruits, was the immediate means of bringing school dentistry to London, where there are now some sixty dental clinics for 600,000 children.

After making acquaintance with the German work, we were able to report : " There is no way of dealing with money in the interests of the Public Health which will return so enormous a gain to the population for the small expense required as this matter of school dentistry. Dentists never touch this class of child, and there is here no competition between the private practitioner and the public servant " (*L.C.C. M.O. Ed.*, 1907. 17). That has been amply borne out by experience. In the last Report (*L.C.C.*, 1924. 59) 256,642 were inspected by dentists, 178,802 required treatment, and 99,045 were actually treated. These are about the proportions at present to expect. Leeds may be compared : Examined 55,134, referred 34,011, actually treated 13,895.

Except in very bad cases there appeared no direct relationship between dental conditions and the state of nutrition. In our first London enquiry on some 1500 children, those with insufficient grinding surface were below the standard weight and height, but those with perfect teeth just coincided with the standards of physique (*L.C.C. Report*, 1905. 11). Observations have since shewn that except for extreme cases the relationship is trivial.

Harvey Sutton expresses it by stating that dental caries is probably a contributory cause rather than the main cause of malnutrition. The worst sets of teeth tend to be found in the ill-nourished, while good teeth are most commonly confined to children above the standard (*N.S.W. Report*, 1918–19).

Rhodes, in the Galton Laboratory, found little correlation between dental and nutritive conditions. Colyer has noticed increase in weight beyond any normal rates, following extraction of septic teeth. Waller demonstrated physical improvement in babies after removing septic teeth from their mothers. Evidently the toxic quality of the sepsis varies, and in some cases has high activity. Auden (1924) thinks failure of normal growth and physical development is but one of the common manifestations of oral sepsis.

In the Report of the Medical Officer for Staffordshire in 1921, results are given for five annual crops of children, and it is stated that 51·2 per cent. of these children, not over their ninth year, had free pus in their mouths. Although free pus is not defined here, the Report shews the extremely septic oral conditions when dental care begins.

Diphtheria carriers are also stated to have oral sepsis, and Royer, after an experience of 7000 cases of the zymotics, considered oral and pharyngeal sepsis as practically common causes in the worst cases.

C. H. Mayo finds the root abscesses and pockets in connection with them common as sources of acute and chronic rheumatism. He also thinks that from the chronic poisoning a condition of anaphylaxis may develop that causes results in hay fevers, asthmas and urticarias (*J.A.M.A.*, 1914. ii).

The main problem of the care of teeth in children is the removal of oral sepsis and its risks by prevention and treatment of caries and diseases of the gums. The only course is to put the mouth into a healthy condition by removal of the caries either by treatment of the affected teeth, or their removal.

Prevention.—The etiology of healthy teeth has been already indicated. The prevention of caries is a matter of healthy diet and regular toileting of the teeth. The treatment is now an arrangement compulsory on Local Education Authorities under the Statutory Regulations (1925. 835), Chapter III. 18 (*c*). "The medical treatment of defects of eyes and teeth, minor ailments and enlarged tonsils and adenoids."

The popular neglect of teeth among all classes in England impressed the late Sir William Osler when taking up residence in this country, and he made many strong statements on the subject.

Surface treatment of teeth given at regular intervals to the school children is service beyond the power of the dentists themselves to give, so much time has to be given to reparation work that it is not possible to cope with this subject of prevention alone. On this account Fones inaugurated his system of dental hygienists. That dentists alone are to work on teeth is a Utopian dream in Public Health organization. Dental hygienists can do all the surface work,

and mouth sanitation necessary in nine-tenths of the cases at a quarter the cost.

Intelligent girls are taken into an institution or college and given a thorough training in the knowledge needed for prophylactic treatment of caries. A considerable number of such training places now exist with different standards. The Columbia University course is for nine months. The New Zealand lasts for two years. It would seem reasonable to suppose that a twelve months' course could be arranged which would enable the workers ultimately to prevent 70 to 80 per cent. of the caries in schools.

The experience of these dental hygienists shew that they can detect dental irregularities and caries with probe and mirror, chart defects correctly, do simple dressings, scale and polish teeth, drill and excavate cavities, make fillings where the pulp cavity is not reached, and extract temporary teeth. Dental hygienists could work under definite conditions on their own responsibility, and as the work develops more and more can be trusted to them. They have come into American and New Zealand schools to stay. Wherever they have been tried, school dental hygienists have been thoroughly approved and appreciated. They are the only means which the writer can see as likely to be extensively employed in the next half-century, and he estimates that there should be ten dental hygienists to every registered dentist working in British schools. The minimum number required for London would not be below 1000. Meanwhile, the English Regulations which affect the performance of minor dental work in schools are the decision by the General Medical Council in 1917 that the supervision of the recognized workers by dentists should be real and not of a perfunctory nature, and the Regulations of the Board of Education (No. 1279) that the registered dentist under whose personal supervision the work is performed must always be present when operative work is being carried on, and must not supervise more than two persons at one time if he is performing operative work at the same time, or six persons if not so performing; must prescribe the treatment and inspect every case after treatment.

These Regulations make school dental work very costly and unpopular. So long as a dentist arranged regulations for the work of these dental hygienists and accepted responsibility it should have been sufficient. Meanwhile progress in this direction is indefinitely slowed down.

A parent who refused dental treatment for his child was fined £5, or ten days' imprisonment, at the Glasgow Sheriff Court in 1923, and this being recorded in a note on the card requesting children to be taken to the dental clinics resulted in marked improvement in attendance (*Glasgow Report*, 1922–3. 3).

CHAPTER VII

RICKETS

Rickets has been an entity since the seventeenth century when Glisson, the Cambridge anatomist, in 1650 described disorders of nutrition and growth so that it has since been known to generations abroad as *Die Englische Krankheit.*

It was first investigated in primary schools by Dr. William Hall (1902) in his comparisons between Jewish and Gentile children in Leeds. He shewed that dental defects varied with other signs of rickets, and thought it dietetic. Recently, Corry Mann thinks diet more important than environment (*Med. Res. Comm.*, No. 68. 1922).

Its results, rather than its activities, persist to school ages, although now its prevalence is rapidly diminishing. Late rickets, a relative pathological starvation, is chiefly seen in young Indian females under purdah conditions, and is very rare in this country. Dr. A. Gilmour noted that boys in Paisley were three to four times as frequently affected as girls, and H. P. Newsholme, in North Yorkshire, notes their frequency also. Gilmour did not find dental conditions differ significantly in rickety and others, and Harvey Sutton, writing on the condition in Australian schools, says that rickety teeth are only seen in children from the Northern Hemisphere (*Med. Journ. of Aust.*, 1920. ii. 190).

The proportions found in school obviously are dependent on personal equation. Rose, in Aberdeen (1914), noted among five-year-olds 40 per cent. boys and 33 per cent. girls. In Edinburgh the same year 0·7 per cent. of all examined were noted as shewing rickety signs, i.e. 68 out of 10,301 had slight pigeon-chest, and 38 bow-legs, and 30 knock-knees.

In the Govan Report of 1919 there were 1675 (20 per cent.) out of 8402 children, and 176 bad enough for cripple schools ; whilst neighbouring Dumbartonshire only returns 64 (1 per cent.) out of 6771.

Deformities, in the way of bossed skull, lordosis, bow-legs, and knock-knees become less evident, but pigeon-breast, scoliosis, and kyphosis, due to this cause seem to increase in frequency in school days. Harvey Sutton thinks that the rachitic suffer most from ill-fitting school furniture.

Mentally, rickety children are generally dull, and H. P.

Newsholme tabulates them as mostly behind in their standards (1922).

Lawson Dick (1916), who made a complete enquiry in the East End of London, found 80 per cent. with signs of rickets. Defect in calcium metabolism is marked in resulting hypoplasia, or defective calcification of dental enamel. He describes a recognizable type of child in school, fat, and as a rule well nourished, though the muscular tone and development are often markedly defective. The complexion is pale and pasty ; commonly an adenoid expression and a bronchial cough. The bones are soft, and hypoplasia is frequent. These children are backward mentally, but are in no sense mentally deficient, though frequently put before the school doctor as such by teachers.

Many facts were known, but unrelated, such as that Autumn-born babies were more prone to suffer ; that rickets tended to recover in Summer ; or that breast-fed children suffered less than others ; and that activity, fresh air, and good sanitation relieved the condition, that relative excess of starchy diet was bad. The flood-time of rickets was the period of rapid growth in length. Nevertheless the exact cause of rickets seemed insoluble. Many factors contributed, but none were determined as the cause.

Eric Pritchard had elaborated a relative want of adjustment between demand and supply of food as upsetting the balance, and tending to acidosis and decalcification, by removal of calcium and other bases. His remedy was phosphuretted cod-liver oil (1917).

Newer work originates with Mellanby, who, by feeding puppies, determined standard diets which would cause rickets. McCollum and others used rats. The difficulty of early diagnosis of rickets was partly obviated by the use of Röntgen examinations. Diminishing the ratio of growth diminished the risk of rickets. Seasonal variation of growth was accompanied by a seasonal variation of calcium and phosphorus blood-content. Activity and light were both found to conduce to good hygiene.

Sunlight was devitalized by passage through window-glass, and the antirachitic effects observed appeared associated with a band of the ultra-violet spectrum, 300 $\mu\mu$ to 313 $\mu\mu$, according to Hess. He could protect rats on rachitic diet by radiating them at 3 ft. from a quartz mercury vapour lamp, and whilst 3 minutes daily protected, 1 minute was not enough. He further shewed, as Huldschinsky had already stated in 1919, rachitic babies began to mend in a fortnight if exposed half an hour daily at 9 ft. from the lamp. By this means the defective calcium and phosphorus of the blood were both increased to the normal.

Mellanby had thought that the balance of diet and its salts were important, but that a want of some particular vitamin was probably associated with rickets. Noel Paton, in Glasgow, aided by cleanli-

ness, fresh air and light, kept puppies on a rachitic diet without suffering. Sweet confirmed this by his observations on New Zealand babies in Auckland (*B.M.J.*, 1921. ii). English and American observers, and the benefits from cod-liver oil found by Chick in Vienna, shewed that rickets is a relative want of calcium and phosphorus in the tissues ; both are needed owing to the demands of seasonal growth, and there is an antirachitic vitamin necessary for their assimilation which is largely associated with, but differs from, the fat vitamin A.

Spinach, which has vitamin A and protects from the keratomalacia due to its want, has no protective effect against rickets, so that here antirachitic vitamin is absent, although the fat vitamin A is present.

The antirachitic material is more persistent on heating, and can be fractionally separated from vitamin A by heating cod-liver oil in air. A teaspoonful of cod-liver oil is said to have the antirachitic equivalent of five quarts of milk.

It had been accidentally found that non-radiated rats were protected if kept with radiated ones, and ultimately this was traced to sawdust in their cages being radiated. Milk may have its antirachitic qualities increased by radiation, and many substances can be thus activated, although the process is reversible by excess of radiation. The action has been associated by Hess with presence of cholesterol in animal cells or substances. Whilst the effect of radiation is stimulating and takes the place of vitamin, it cannot wholly replace vitamin over long periods. Its effect is curative rather than permanently nutritive.

A definite attempt at community control of rickets is being made (1925) in New Haven, Conn. Each birth certificate goes to the Sanitary officers, and nurses visit and explain the benefits of light and cod-liver oil to the mothers. The children for a time are being controlled by Röntgen examination, but once the demonstration has become a working service this will be unnecessary. They have found that a certain amount of rickets is demonstrable by radiography before the clinical evidence is clear. In many cases of rapid growth this is a kind of physiological rickets easily compensated later (*J.A.M.A.*, 1925. ii. 656). For these large, quick-growing children antirachitic protective treatment is desirable.

A recent Report, for 1924 in Bermondsey, explains the prevalence of rickets to high tenement buildings, the airy and light neighbourhood of the river being comparatively free.

CHAPTER VIII

LIGHT AS A HEALER

Enquiries on nutrition and rickets in relation to vitamins have opened up a new means of therapy by Light, or rather radiation which accompanies light. This can take a part in metabolism for a time at least, as substitute for vitamin.

The universal ether is capable of conducting vibrations of an infinite variety. Wireless Hertzian waves extend from centimetres to thousands of metres in length, and are continuous with the vibrations which constitute radiant heat; then visible on to the Röntgen rays in millionths of metres.

The solar spectrum, which as a band of light produced by refraction through a prism stretches in visible colour from red, through orange, yellow, green, blue, indigo, and violet, was found by Herschel to have invisible heat rays beyond the red. Later photographic methods have demonstrated at the other end ultra-violet rays of great extent and chemical power. Far beyond them are the Röntgen rays of almost atomic size. These wave-lengths are not measured in metres, but in micromillimetres, a millionth of a millimetre written $\mu\mu$, or, more generally, in Ångstrom units Å. or A.U., which is ten-millionths of a millimetre, or A.U. $= 10^{-8}$ cm.

The dark heat rays are more than 7700 A.U. The visible spectrum stretches from 7700 dark red to 3900, the just visible violet, which is the limit of visibility at the other end.

Ultra-violet Rays.—Till recent years the only utilizable source of violet rays was sunshine. Much of that radiation is cut off by the atmosphere or other materials. Ordinary window-glass cuts off all rays shorter than 3400 A.U. A special glass has been made—"Vitaglass"—but it is very costly. It allows rays to 2750 to pass. Another commercial material, "Windowlite"—acetate of cellulose stretched on wire netting—also can be used as a glass substitute and is transparent up to 2750 A.U. Quartz is used in researches and in optical lamps, as it allows rays to 1850 to pass.

However bright sunshine may look if it has come through window-glass, it has lost the vitalizing rays which influence growth and nutrition. Its brightness is a psychological delusion, and it is merely a nuisance to the eye at work. For good effects windows

must be open, or material in them translucent for all radiations down to 2800 A.U.

The atmosphere filters off the violet rays by its higher layers. The longer heat waves can penetrate far, and are not absorbed till the lower strata, which they warm. The higher the place of observation, the lower the temperature, the greater the amount of sun radiation received, and the higher the proportion of ultra-violet rays. This is the reason for the stimulating effect on growth and spirits, of residence in high mountains.

In 1919, Huldschinsky (*Deut. Med. Woch.*, 1919, No. 26) noticed that the light of a mercury-vapour lamp helped to cure rickets. It was the ultra-violet rays of less than 3000 A.U. which seemed effective. Finsen had used light for twenty years in the attempt to

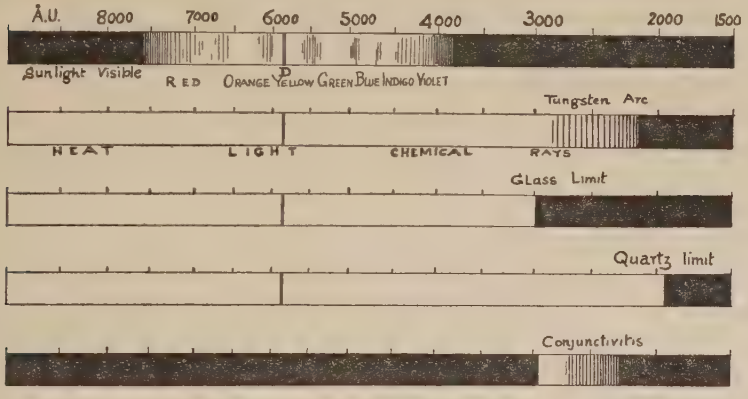


FIG. 30.—THE SOLAR SPECTRUM, AND SPECTRA SHEWING VARIOUS LIMITS OF RADIATION TRANSMITTED.

kill bacilli in lupus. This work, and also that of Rollier in the high Alps, in curing bone tuberculosis by exposure to sunshine could now be extended.

Sunlight has only about 1 per cent. of ultra-violet radiation. On clear days about 75 per cent. of the sun's radiation reaches 1800 metres level, but only about 50 per cent. sea-level.

Leonard Hill has devised a method of estimating amounts of ultra-violet radiation by its bleaching effect on an acetone methylene blue solution in quartz tubes.

The great smoke cloud of the West Riding, as Sir J. Crichton Browne described it many years ago, diminishes the effect still more, and impairment of vitality shews alike in dwarfed children and dwarfed trees, thus deprived of solar energy. Recent developments of high-power sources of light have given means of producing abundant ultra-violet radiation, either by use of naked arcs or by using quartz instead of glass in any optical arrangements.

The potentialities of these rays are not yet fully explored. Travellers in the Alps often complain of snow-blindness, and mountain guides get inflammation of the skin of their faces. This is the reaction to violet rays reflected by the snow. There is quite a small range that cause trouble ; 3020 A.U. pass the cornea undiminished, 2970 A.U., however, are stopped and cause conjunctivitis. This band is shewn diagrammatically in the last spectrum on the figure. It is, therefore, necessary when working with sources of ultra-violet light to protect the face, and goggles of dark-blue glass or Crooke's No. 4 should be worn.

Two distinct groups in the ultra-violet of ordinary sunlight are those of wave-length over 2960 A.U. having no bactericidal action, and those shorter than 2960, which are absorbed by bacteria and quickly destroy life in cultures. Very powerful effects are produced also by much shorter Röntgen rays, not now being considered.

The ordinary white-flame carbon lamp is safe and slow. It gives out much heat, and the room has to be well ventilated. Hill recommends one of 100 volts and 30 amperes. By using a core of Tungsten powder a more intense violet ray production is ensured, and time of exposure shortened to about a quarter. The material, however, is rather costly.

Open long flame arcs are preferable where numbers are to be irradiated at a time, and children 4 ft. away from the arc can run about for 5 or 10 minutes with safety. The quartz-mercury vapour lamp is also a powerful source, but it has to be watched carefully not to produce a burn. The quartz requires cleaning from time to time to maintain efficiency, and it is only suitable for private cases, not for numbers at a time. Workers with radiation are well satisfied with results. Rickets can be prevented, septic wounds or ulcers tend to heal, and chronic tubercular ulceration cleans up in an astonishing way. Great care has to be used not to overrun an optimum dose. Some cases of phthisis in sunshine or with radiation re-act by a flare-up.

Children do best under treatment. They improve in metabolism generally ; muscles are firmer, and the youngsters seem mentally brighter.

The effect of radiation is not yet understood. Its specific effect in therapy is to aid assimilation and storage of calcium and phosphorus in tissues. With the optimum dose there is the faintest flush of reaction in exposed skin. The rays have very slight penetrative power, and Hess thinks their effect is a physical one on cholesterol in animal, and phytosterol in vegetable, cells. Certain pigments prevent the action, as the carotin of carrots, others oversensitize. Hæmatoporphorin, if present in the blood, sensitizes to a dangerous extent.

The pigmentation of skin which takes place is in a measure protective.

CHAPTER IX

SLEEP

Sleep is part of the rhythm of life, but its cause or mechanism is uncertain. "Half our time is passed in the shadow of the earth," and although we use it mostly for sleep, it is as a habit. Many animals do not. It is a nervous phenomenon not only of highest levels, but of middle and even low levels of the nervous system. Attention ceases first, each nerve cell needs a time of repose to repair its machinery. It is not only the highest levels, but all the middle levels which attend usually in their reflexes to the varying environment, all are gradually more and more withdrawn as repose comes on.

Yet mental associations seem to be going on all the time. Education is going on during sleep. The pulse is quietened, the consumption of oxygen diminished. There is no single word to express the building up, the anabolism, storing and restoring, and process of repair that goes on in the machinery of life's activities.

It is also a kind of defence against exhaustion, as with tiredness comes the necessity for sleep. It is also an ancient habit, when the suggestion of rest and quiet is offered, almost automatically advantage is taken and sleep comes. Absence of external stimulation, a monotony that tires the attention by not insisting on its need, the dim religious light, the intoning voice of the preacher, quietness, restfulness, and safety induce sleep.

Drugs, toxins of fatigue or disease, endocrine disturbances may all conduce to sleepiness. The fat boys with dyspituitarism are also sleepy boys. How these things act is not known.

The growing neuron, with no reserves, wants more repose to build up its machinery than it does when reserves are developed and established. Extra sleep is correlated with immaturity and growth, as well as with maintenance of life. Manaceine determined that sleep is even more necessary than food for young and growing animals.

It is difficult to know the amount of sleep needed as an optimum. Probably with good vitality and vigorous circulation the need of repair is not so great and prolonged sleep less necessary than when debilitated or convalescent.

The Caldecott Community Schools, residential for poor children, find that the poor child is always a year behind the rich one in

mental age. This they ascribe to lack of sleep. When toddlers first arrive at the school they sleep for 19 hours out of the 24, whilst children of 6 and 7 years will sleep for 14 hours when they return after holidays at their homes.

Sleep means relaxation. The tone of the circulation is so relaxed that the blood-vessels in the limbs and viscera are filled, and there is comparative stasis and anæmia in the brain. Armstrong Jones demonstrated by callipers that a hernia cerebri had shrunk during sleep.

The depth of sleep is variable, and has been tested by the strength of various stimuli needed to waken the sleeper. This may be noise

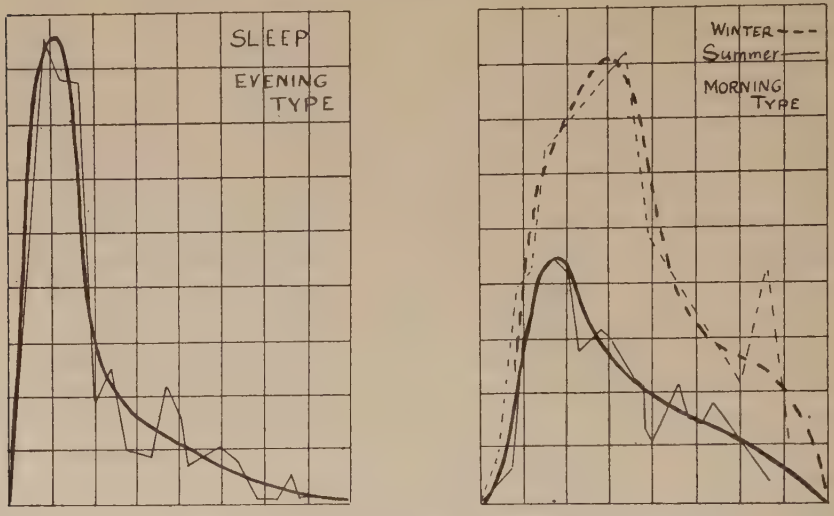


FIG. 31.—RELATIVE DEPTH OF SLEEP CHARTED AT EACH HOUR FROM COMMENCEMENT.

of a falling body, brightness of light, or an electric stimulation. Michelson made out two types of sleepers; the evening type who sleep heavily at once, as most children do, and the morning type who distribute the depth of their sleep more evenly over the period.

The first type awake ready for work, the second take some time to warm up to their best effort.

Deprivation of sleep when it is real will cause diminished mental efficiency. Much sleep comes which an individual is not aware of. Seashore regarded everyone as being better for a midday nap. He thought it was economy to cut short long morning sleeping hours and substitute a twenty-minutes' sound sleep at midday as the most effective relaxation for subsequent good work.

Children who sleep in the afternoon do not sleep so deeply or reach the maximum depth so soon, but sleep better from the fourth to the eighth hour compared with others. In the case of adults,

the amount of sleep required varies much with the individual. Probably it ought not to do so with children.

Clement Dukes gave the basal estimate, sloping from about 14 hours for a five-year-old, to 9 hours at 18. Miss Ravenhill, from a questionnaire, set out hours varying from $10\frac{1}{2}$ for the six-year-old to about $8\frac{1}{2}$ from 12 onwards.

Terman and Hocking (*J. Ed. Psych.*, 1913. 138), with Californian children, testing the time of spontaneous waking, gave a curve from 11 hours at 6 to 9 hours at 13. They found sex differences very small.

Sakaki, who studied the recovery of tactile sensibility after sleep, thought boys needed more sleep than girls. He laid down

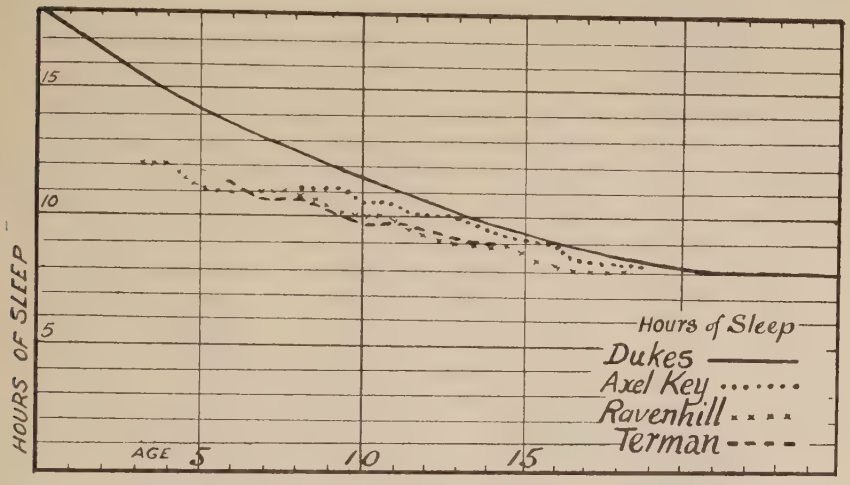


FIG. 32.—AMOUNTS OF SLEEP DESIRABLE AT VARIOUS AGES.

the rule that Japanese girls, age $9\frac{1}{2}$ to $11\frac{1}{2}$, must have $9\frac{1}{4}$ hours' sleep at least, and for each year younger half an hour longer. Boys must have half an hour longer than girls of the same age. Miss Ravenhill actually found that the younger boys averaged half an hour longer than girls. This is in complete agreement with all other facts pointing to the relative precocity of school-girls.

Terman could trace no relation between sleep and the mental occupations of school.

Acland's enquiries at English public schools and corresponding American institutions found that American scholars aged 14–16 had about an hour more sleep than English boys.

Miss Ravenhill's enquiries were in English elementary schools, with the results charted in the figure.

Sir Charles Sherrington thinks : "Most of a boy's growth in stature is done in bed, and there mental and physiological recreation

goes on most efficiently; without plenty of sleep the activity of the waking day is like a house built on sand."

Housing is the real problem of insufficient sleep. Other factors are several crowded in a bed, and possibly also in the poorest homes, the irritation of vermin. Actual overwork for want of sleep is rare except in occasional secondary school girls more ambitious than capable. The effects of want of sleep, when the want is maintained over long periods, may shew in physique, but there is no very clear indication of what this amounts to. In young children the

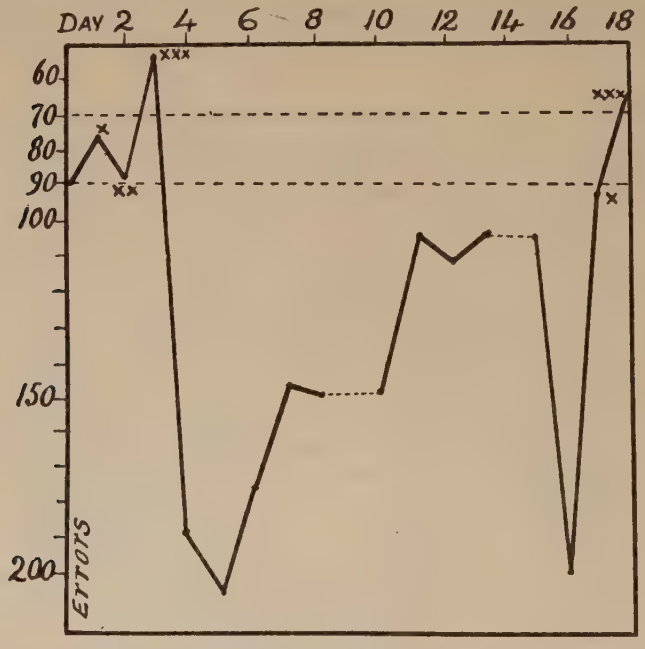


FIG. 33.—FATIGUE CYCLE SHEWN AFTER THREE SUCCESSIVE NIGHTS WITH *1½, **3½, AND ***5½ HOURS' SLEEP RESPECTIVELY.
The dotted lines give extreme normal variations (from May Smith).

effects of plenty of sleep seems correlated to good growth. Veeder, of St. Louis, insists that ill-nourished children, who do not improve by feeding, are living at an excessive rate mainly from want of rest. Two-fifths were underslept (*J.A.M.A.*, 1921. ii. 758).

Miss May Smith, using the dotting machine and other tests, endeavoured to determine the want of sleep on subsequent performances (*S.H.*, 1919. 62), and shewed that the effects were very persistent, but there was a short phase when want of sleep acted as a temporary stimulant. The immediate effects of three nights of diminished sleep are either normal records, or records shewing a diminution in the number of errors. As soon as the loss is made up by extra sleep on succeeding days errors rose, and continued high

for sixteen days. The curious thing was that neither subjective feelings nor judgment of the working efficiency gave the observer any indication of the real condition of her performance.

After the duration of sleep is three-quarters over, the gradual recovery leads to many middle level performances in response to stimuli. These may also call into action the higher levels of the consciousness, and various kinds of action take place. Certain nervous automatisms easily come into play, usually sympathetic irritations setting up conditions of night terrors. The child may appear in a condition of terror or horror, and yet not be clearly conscious or realize where it is. These conditions sometimes appear to be related to the unstable, nervous, or even possibly epileptic disposition in the child. Adenoids may play a part, certainly operation appears to give relief, whether by a kind of suggestion it is impossible to say, as the same relief occasionally happens with children subject to enuresis. Endocrine action in the way of small doses of thyroid extract also is effective in some cases.

Enuresis.—Enuresis, or nocturnal enuresis as it is termed, is an infantile habit retained beyond its time, chiefly in low-grade children. It may also be retained as a conditioned reflex set up by improper training in pre-school age, or maintained by some local irritation requiring remedies. Cameron has set this out well, and classes it with hysteria.

The old treatment of belladonna and cutting off fluids late in the day, whilst sometimes of avail, as any medicine may be which has a suggestive local effect, did not avail in pronounced cases. These each require a careful study to ascertain possible causes. Removal of adenoids, treatment of local conditions, thyroid medication occasionally does good. Treatment by suggestion should be helpful, but care must be used lest the suggestion confirm the habit. There should also be discomfort associated with the habit. Frequent waking up at night, sometimes cures girls who do not like the disturbance. With boys, a plank bed on each night succeeding a fault might be worth trial.

A few cases seem incurable. The low-grade mental case that shews a hairy patch over the upper part of the sacral spine is as a rule incurable. The use of an india-rubber urinal to be worn at night has been efficacious in some industrial school cases.

CHAPTER X

THE SPINE

Traces of the long train of ancestry shew like fleeting shadows in the early history of every child. Robinson, a generation ago, startled magazine readers by narrating how new-born babes gripping a walking-stick could support their own weight, yet the young infant on the ground only makes meaningless movements, and is a long way still from the definite controlled actions for progression. Mumford suggests that the limbs flap about like the relics of some swimming animal. When actual progression is attained the crawling baby is a quadruped. With time it sheds this capacity, so that in older children creeping exercises, when prescribed, are found difficult and unpleasant. In the nursery school age and baby-room the power of creeping still remains good, is delighted in, and enjoyed by youngsters, and should often be worked into their games as a relaxation and amusement.

Creeping up and sliding down boards they will find out for themselves whenever the chance offers. The first efforts at erect posture ought to be spontaneous ; premature encouragement is no advantage. The child hauls itself up, it leans forward and clutches something for support. It clutches its mother's skirt, it holds on to furniture, it cannot stand alone. It supports its body by the arms as do anthropoid apes. Keith describes it as having the spinal proportions of a chimpanzee. At last it evolves the human upright position and emerges into the world around as a toddler, somewhere in its second year of life.

Soon another human peculiarity, the lumbar curve, begins to be evident. This goes on developing all through the elementary school age, attaining completion about the twelfth or thirteenth year. Through this period the spine is plastic and variable. With appearance of the lumbar curve come other changes. The cervical and dorsal curves develop in the sixth to eighth years, and the narrow-keeled thoracic cage of the quadruped flattens out to a broad chest about the fourth or fifth year. Even then attitude alters with varying growth of different parts of the body, and it is not till adolescence is over that the graceful freedom of full growth is attained.

With attainment of the upright posture freeing the arms from necessity of acting as auxiliary supports, a co-ordinated hand and eye mechanism gradually comes into existence. This in the long history of the past was precursor of high intellectual development. With freedom of the hands the body weight has to be taken entirely by the pelvis, on which the body with its spine is now wholly supported. The pelvis became broadened to give a wide base for the spinal controlling muscles. The upper spine in the thorax was held by muscles acting on the ribs like long levers controlling the vertebræ. The broadened human chest here gives the muscles full control in preserving balance of the upper part. It is muscles, not ligaments, that maintain the spinal position.

The upright posture being late in development is still a variable quality. The child going upstairs has to hold on till about $2\frac{1}{2}$ to 3 years old. In the infant and nursery school child development of good posture is of higher importance than any other education, and biologically only second to good nutrition. Its full possibilities depend on good nutrition, daily rest in sleep intervals, and subconscious training through free games and purposeful balance movements of continuous difficulty.

The body has an heredity which makes it grow in certain ways, and which results in potentialities only brought out by function.

Girdlestone notes that in a child with a limb completely useless as a result of infantile palsy, although the limb cannot be used, it grows quite normally in shape and proportions, but very much smaller than the others. Many children with flat back and having poorly developed loin muscles are found in schools. They are mainly children who from illness or otherwise were late in walking, and as a result have insufficient development of muscle.

This upright human posture has meant an enormous readjustment of machinery in the alteration from a horizontal to a vertical spine. All the changes of position of muscles and joints, of blood circulation and lymph flow, all the various reflexes have been corrected and adjusted, and control maintained through the ages. The complex proprioceptive nervous system deals with movements and position of the body, and from the pressures, stresses, and strains of muscles and ligaments and internal organs makes necessary corrections and alterations subconsciously and automatically, rapidly as the winking of an eye, and yet constantly and almost tirelessly. This constitutes a large part of the personality. It is related to the emotions, and is part of the intellect. Partly inborn and partly developed through practice, partly learned as educated skill, this muscular sense or motor capacity, which makes the great cricketer or gymnast, singer or orator, and equally the performer on the fiddle or the fine artist, depends on the retention of kinæsthetic memories in the subconsciousness, so that every movement is recalled in its essential

TUBERCULOSIS ASSN.
STREET

sensations, and shorn of that which is unnecessary or redundant in the finished performance.

Good spinal attitudes representing the minimum nerve waste, the smallest stress and strain and the maximum result from their balanced action, for this reason become important as habits of life not only physically, but mentally. Probably the nervous mechanisms, especially central ganglia, on which these actions depend are much affected by endocrine variations, but this is too indefinite yet for more than theorizing.

The writer has tried to adumbrate a doctrine that in any academic physical training for young children the only exercises of truly educational value are purposeful body balance exercises calling for constant adjustment of posture mainly by subconscious action. They should allow little deviation from correct positions, and be of constantly progressing difficulty. Beside a system of exercises for this purpose all separate movements are educationally of trivial import except in so far as they elicit good balance and stimulate respiration and circulation. A further reason is that these balancing exercises cannot be of harm to any child, as the strain comes mainly on subconscious mechanisms which cannot be abnormally forced to premature action.

These postural reflexes which control the spinal attitudes are almost absent in the infant, and are developing in the second to the fourth year. They are easily upset ; a little disturbance of stomach or skin may throw an infant off its feet for days. They may never be fully learned, as is shewn by the number of men entering universities who do not know how to stand correctly. Only 20 per cent. were normal at Yale in 1922 (*Am. Phys. Ed. Review*, 1923. 169).

Erect posture of the spine should become habitual, but voluntary attempts to maintain an accurately upright posture gives no relief to muscles. Sir Arthur Keith notices how fatiguing this attitude is. The short levered muscles of the spine easily yield, whilst the long levered rib muscles, acting at greater advantage, still maintain the attitude. The yielding muscles are rested by allowing the vertebræ to rotate so that the articular processes begin to lock, and the transverse processes rest on the necks of the long costal levers. This is the beginning of lateral curvature as a functional result of fatigued muscles.

The normal spine would be that in which with head erect, chin in, shoulders thrown back, chest raised, and abdomen flat there would be a slight concavity forward in the thoracic region and slight concavity backwards in the lumbar spine ; the pelvis being at an angle of nearly 60° with the horizontal.

There is no absolute normal in any animal measurements, but within wide limits all kinds of variations, short of, or in excess of, a normal, in any of the various factors ; and yet the individual is

quite healthy. There is no normal straight spine in an antero-posterior vertical plane, but an infinite variation at different levels to the right and left of this plane, and yet all perfectly healthy. Probably four-fifths of recorded cases of spinal curvature ought to be included in these normal physiological variations, simply due to the human being not being absolutely symmetrical. Slight degrees of curvature have little importance. The majority of children enter on their teens with round backs, and in most of them it has disappeared in the next half-dozen years.

The healthy spinal attitude then is maintained by muscular action which is controlled by nervous mechanisms. Muscles have

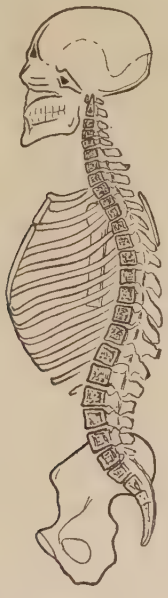


FIG. 34.—NORMAL CURVES OF SPINAL COLUMN.

two actions. There is muscular or postural tone which, whether the muscle is lengthened or shortened, acts slowly, ceaselessly, and almost tirelessly to maintain the constant positions taken up. The other action is the ordinary rapid, voluntary, or reflex muscular action, but it is immediate and easily exhausted. These actions vary in different muscles. Flexor muscles are almost without the postural tone, which chiefly acts through the anti-gravity muscles—that is, those which maintain attitudes against the tendency of gravity to alter them. This postural tonus in the spinal muscles maintains the extended position of the body. Lowered tone in the nervous system, with all its concomitants emotional, mental and moral, is shewn by the relaxed slouching attitude with head bent forward and joints all a little relaxed, producing the picture of a round back,

probably slack knees and hips, and possibly everted and flat-splay feet. Postural tone develops in the young child slowly. There is some connection between tonus and the position of the head. The head stooping forward is connected with diminished tone, but carried well up tonus increases. Reflexes from the labyrinth also are involved. In a knock-out blow on the tip of the jaw concussion of the otocysts in the internal ear leads to an instantaneous reflex abolition of all the postural reflexes, and under the action of gravity the individual drops a mere mass of flesh and bone (Sherrington). Here, again, the author's call for difficult balance exercises for young children is confirmed.

The subject deserves full study from the school point of view. It has been reviewed by Bankart (*B.M.J.*, 1921. i. 587), and also later by Arnold (*Am. Phys. Ed. Rev.*, 1923. 361).

Prevalence of Spinal Variations.—No school doctor can examine children without noticing the many differences from the ideal straight spine. Dr. Annie Gowdey, in London, inspecting large numbers of girls in elementary schools to estimate the prevalence of tuberculosis (1907), notes that 64 per cent. shew some abnormality of the back, 50 per cent. having scapulæ, "growing out," and 15 per cent. round backs. At the same time, Dr. Janet Campbell, inspecting girls in secondary schools, noted 23 per cent. shewing scoliosis, but only 1 per cent. did not admit of postural correction.

Spine in Debility.—The projecting scapulæ also mean poor musculature, and many of these children shew feebly developed muscles. The weight of the arms drags down the poorly supported tips of the shoulders, and causes the scapulæ to project. Apart from this the nervous control of the muscles may be wanting either from fatigue or debility. There are plenty of fat girls with well-developed muscles in secondary or private schools whose backs are "growing out" from a debility that is not muscular, but in the muscular control. One congenital defect occasionally seen is the scaphoid shoulder-blade, the inner edge shewing a concavity instead of the normal convexity. As it does not alter with age, and is relatively rarer in adult life, Kollert, in 1914, suggested that it gave a bad prognosis for future life, rapid phthisis being a frequent occurrence.

Fatigue temporarily gives a picture of the variation from normal as seen in functional spinal changes. The head and neck droop forward and are balanced by the upper part of the trunk going back with flattened chest, whilst the lower part goes forward and abdomen protrudes.

Flat Backs.—In children with poorly developed lumbar muscles the normal curves are less obvious. There is a flat back which shews especially when they are seated. The other signs are those of fatigue. The infantile spinal form is retained with the forward

thrust of the thorax and retracted abdomen, whilst the shoulder blades stand out. Watts's picture of " Love and Life " has a female figure with the typical flat back, possibly intended to accentuate the idea of juvenility. Flat backs are strangely about twice as common in rural as in urban children, and the proportion scarcely alters with age. They are probably mostly rachitic, but heredity may also have a share. If the pupils are exercised with a view to develop their chests, other subsidiary benefits will follow.

Kyphosis.—The round back or kyphosis when the spine is bowed forward wholly or in parts, and a convexity faces posteriorly, may be part of the generally debilitated attitude from defective nervous tone, and then often accompanies some slight lateral curvature, and sometimes flat-footedness.

About a third of the men entering Yale are recorded as needing treatment for kyphosis. When this is mainly in the region of the fifth to eighth dorsal vertebræ, with flat feet and a lumbar lordosis, improvement is usually slow and treatment has to be prolonged. The drooping shoulders, winged shoulder-blades, and forward thrust neck are characteristic. The pelvis is nearly horizontal, and whilst the axis of the body in profile normally passes in front of the ear, in kyphosis it passes behind.

The round shoulders of school children are mainly outgrown after puberty, but when the condition remains fixed, with contracted chest and other lateral curvatures, treatment is necessary.

The curvature is not necessarily due to weak muscles. It may be a result of prolonged fatigue, or be the result of attitudes maintained from myopia, or from continuous work on small objects in poor light. It is often due to nerve weakness, or mere laziness and weak will.

The treatment for round backs is plenty of exercise and general tonics. Gulick's advice to feel the collar stud at the back of your neck is useful here. If the head is held well back and there is plenty of exercise to develop the chest, improvement will follow.

Lordosis.—Lordosis embraces curves with the convexity anteriorly. The commonest variety is lumbar, constituting the hollow back of German writers. It is often exemplified in marching infants trying to be little soldiers or holding themselves up. There may be combined curves kypholordosis, but as functional curves they are very rare in children.

Just before the War, Kemsies studied the attitude of children at work (*Jahrb. f. Schulges.*, 1914. 135) by means of photographs. Blumenthal's method was also used. In this a number of horizontal parallel strings in a vertical plane have their ends attached by plaster along the spine. The other weighted ends pass over small pulleys on a vertical rod. On each string, at an equal distance of 12 or 15 cm. from the spinal end, is a glass bead. These

beads form a column of the same shape as the spinal axis, and with every spinal alteration in the vertical plane there is a corresponding change of the column of beads. By such means the various attitudes of children were analysed. Kemsies stated that it was impossible to sit continuously with an upright spine. He figured four positions for reading, writing, hearing, and resting in Rettig desks, and advises short lessons with frequent rests to give relief to the postural spinal muscles. The interesting point in his

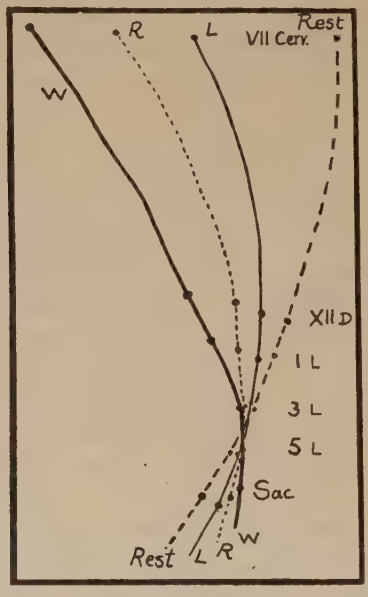


FIG. 35.—SPINAL CONFORMATION AS DETERMINED IN POSITIONS ON RETTIG DESK.

Writing W, reading R, listening L, and resting Rest. The positions of various vertebræ noted. (Kemsies.)

work is that the fourth lumbar vertebra seems to remain almost in the same position in all these attitudes.

In these anteroposterior bendings no account is taken of the comparatively rare Pott's disease—an angular curvature due to tubercular disease. A tubercular spine presents pain, rigidity, weakness, and deformity. There is a general stiffness, the child guarding himself from all pressure or twists, and supporting weight, if possible, by the arms. Pain is produced by certain movements, and referred to the distribution area of various spinal nerves. Disease of the cervical vertebræ may thus shew as wry neck. The lumbar affection may present the over-erect extended attitude or lordosis. There may also be evident backward projection of the affected vertebræ. Doubtful cases require expert examination.

The various forms of lordosis predispose to lateral curvatures or scoliosis. Formerly scoliosis was looked on as a school disease. Staffel called it a "Sitzkrankheit," or sitting disorder; Lorenz, in 1896, called it the professional disorder of scholars. Cohn assumed that it was chiefly caused by writing. It is true there were varieties recognized as having nothing to do with school.

There is a congenital scoliosis usually associated with a supernumerary rib. A compensatory curvature forms the scoliosis associated with the displacement of the head in congenital wry neck. Early rickets also causes deformity with subsequent compensatory curvatures, and the extraordinary specimens of contorted spines seen in museums are generally the final results of such early rickets. There is also a compensatory scoliosis in unsymmetrical position of the pelvis. If one side of the pelvis is raised the sacral and lumbar spine will be tilted over towards the other side and a compensating curve occurs higher, which bends the spine towards the side on which the pelvis is raised. This unsymmetrical position of the pelvis may be due to the shortening of a limb, or the results of palsy or disease; or to functional performances the result of unilateral pain, or one foot being flat. These are all cases in which exercises are not likely to be of any use in relieving the spinal curvature.

Occasionally, in nervous breakdown of girls in their teens, or in psychasthenia, or possibly larval forms of dementia præcox, strange habit attitudes of the shoulders or spine may last for months purely as nervous expression.

Strictly speaking, any lateral deviation of the spine is scoliosis, but it has also been suggested on a previous page that four-fifths of these recorded would be better classed as mere physiological variations.

Lordotic Albuminuria.—An intermitting or cyclic albuminuria in children and adolescents associated with exercise and the upright position has long been known. Clement Dukes (1907) found it in 16 per cent. of Rugby entrants, and relieved it by calcium, either in large quantities of milk or as lactate.

Jehle, in 1908, recognized lordosis as usual in these cases (*Funktionelle Albuminuria*, Wien, 1923). Langstein held that it was orthostatic, and Jeanneret that whilst no single cause is effective, lordosis, orthostasis, and immobility produce it in about half the cases under 14 tested (*Arch. de Med. des Enfants*, 1915. 461).

Lury, earlier, had connected it with pressure on the kidney, and Sonne, of Copenhagen, starting on the supposition that as the kidneys were on a different level one would be more affected than the other, determined by catheterization that it was invariably the left (*J.A.M.A.*, 1921. ii. 127).

These observations have been applied by Peiser, who noted it frequently as due to the sitting position with arms crossed behind,

a position which he says should be forbidden (*Zeit. f. S.*, 1911. 311). He found that merely maintaining the waiting children standing in a strict drill position produced the effect in many.

Scholder, in Lausanne, with 1254 children, found that certain lordotic attitudes produced the effect in 20 per cent. of the children (1914).

In certain growing children, therefore, vasomotor instability, which may be relieved by abundance of calcium as lactate or as fresh milk, is likely to produce albuminuria if the kidney circulation is interrupted sufficiently by immobility, and the pressure of an upright position with considerable amounts of lordosis. These conditions should not persist in drilling or school attitudes. Boys in Framlingham College, tested on two occasions, shewed 25 per cent. out of 189 boys. The detection of this symptom alone need not be taken too seriously, but it suggests care in regard to certain exercises.

Examination of Spine.—Inspection of the backs of all children is required. It is important as occasionally scoliosis may be the evidence of deeper disease not otherwise obvious. Slight degrees are either not worth special treatment beyond attendance to general health, or they may be easily remedied by simple school means, or lastly, they may be organic and call for careful treatment by exercises or appliances to further progress, or even aid some recovery.

For inspection of the back, stand the child, unclothed to a level about a couple of inches below the iliac crests, just exposing the sacrum to the gluteal cleft. It must be in a good light, and is better facing a dark wall or blackboard, across which a broad chalk-line has been drawn about level with the child's ears. Two vertical lines, about 30 in. apart, to shew on each side of the body, are also useful as reference lines and help to dispense with other levels or instruments. A dark string hung so that it can be used as a plumb-line near the child's spine may rarely be useful. The examiner, viewing the back, looks for asymmetry. No human being is quite symmetrical, but certain points are noticeable at once, differing heights of the shoulders or unequal prominence of the hips are the first signs of obvious spinal curvature. The shoulders and hips should be in the same vertical plane. The waist triangle, two equal sides formed by the side of the body and the base by the arm hanging loosely, should be equal and symmetrical on either side if the spine is normal. The shoulder-blades may shew asymmetry, the inner edge of one being nearer the spine if there is curvature in that direction; the angle of the scapula will also stand out.

When curvature is not obvious, running down a couple of fingers, one on each side of the line formed by the spinous processes, some-

times in a few seconds, brings out a red line which makes any curve obvious. The child is then told to stoop over and touch its toes without bending its knees. A spinal curvature will probably disappear in this position, but, whether or not, the level of the two prominent ridges of the back should be estimated to see if the muscular ridge shews more on one side than the other. If there is unequal level it shews rotation of the bodies of the vertebræ towards the higher side. Turning the child to face the examiner the level of the shoulders is again noted, and the symmetry of the chest estimated. Postural curves usually disappear at some point in this examination. They are generally long C curves convex towards the right, and if it is possible to imitate them in the normal spine

FIG. 36.—SEVEN RECORDS OF GIRLS' BACKS.

The dotted lines indicate position before, and continuous lines after, a term of treatment. (Richards.)

they may be diagnosed as postural (Elmslie, *School Hygiene*, 1914. 139). It is very rare to find S curves in children.

Dr. Florence Richards describes how she keeps records in the High Schools of Philadelphia (*School Review*, 1914. 157). A strip of slightly adhesive plaster 6 in. wide and 2 ft. long is applied to the bare back. With a blue pencil the spinous processes are marked by a dotted line ; the tips of the shoulder-blades by dotted angles ; and the position of the sacroiliac joints by dotted crosses. The plaster is then removed, numbered, and stored in a special book till the end of the term. It is then re-applied, and the various landmarks gone over with a red pencil. The alterations which are the result of exercise, treatment, or growth are then evident. As the girl's own intentions and will are more important for improvement than anything else these records are a useful aid in the way of suggestive therapy.

From inspection a good estimate should be formed of the condition of the spine. There are the three conditions to be taken

into account. Physiological variations making up most of the slight deviations are of little account, requiring neither exercises nor treatment beyond the wholesome regimen of general constitutional hygiene and education.

These slight conditions are generally easily remedied by the voluntary straightening up of the child on being told "make yourself as tall as possible."

Functional, postural, total, school, static, or false scoliosis seems mainly a nervous product from chronic fatigue or weakness of the postural reflexes, and later possibly a condition of slowly attained contracture of muscles, an early stage in the fixation which may follow.

In true, essential, osseous, organic or structural scoliosis, where anatomical change prevents the curvature being temporarily remedied by position or changes of posture, there are usually abnormal curves in opposite directions. Often the spinous processes shew a very sharp change in the curvature. There is generally rotation of the vertebræ, with some rigidity of the spine. Rotation shews up as a backward displacement or bulging of the thorax or loin region on the same side as the convexity of the curvature.

Structural scoliosis is the important form equally common in boys and girls. It increases in prevalence with age, but Kirsch, of Magdeburg, notices that seven times as many cases begin before school age as after it.

On inspection a child may have all the appearance of considerable osseous scoliosis, even with rotation of the vertebræ, yet the whole malposition is remedied in certain attitudes, the condition being purely postural. Some of these cases, where full replacement does not occur, are difficult in diagnosis. School exercises are useless with structural defects, and may even do harm ; an accurate judgment is therefore necessary. Dr. Houdre, in Paris (*La Med. Scolaire*, July 1922), makes what she calls a *silhouette graphique* in doubtful cases. She measures the height by the sinciput A, the acromial angles $B\,B_1$, the line of the waist $C\,C_1$, and the anterior superior iliac spines $D\,D_1$. This gives an immediate selection of all with asymmetric shoulders.

In the *silhouette graphique*, Fig. 37, shewn, the continuous lines represent a healthy child, and the dotted line the outline after a course of physical exercises.

If there is simply a want of equilibrium in tonicity of the muscles of the two sides it is easily remedied, but if the change is osseous and likely to advance it can be distinguished. In the first variety there is usually no thoracic deformity ; if there is, the case wants very systematic handling. The deformity shews up at once because with osseous changes the horizontal section of the chest becomes an oblique oval with diameters of differing length. Measuring the

diameter of the chest from the point on the rib immediately below the right nipple to the rib below the left angle of the scapula gives the right oblique diameter. Similar measurements on the other side give the left oblique diameter. A difference of more than a centimetre in these diameters suggests osseous deformity. An additional check would be measurements from each acromion to the top of the spinous process of the fourth lumbar vertebra.

Scoliosis was at first thought to be school produced. Lorenz, in Vienna (1896), declared that it was a school disease, and

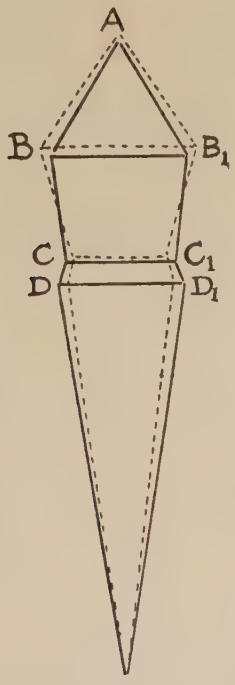


FIG. 37.—SILHOUETTE GRAPHIQUE OF HOUDRE.
Continuous lines before, dotted after, a course of exercises.

numerous writers related it to desks, or to attitudes in writing, carrying books, and so on. This would be a solution if there were no congenital cases, if it did not occur before school ages, if all school children and only school children were affected, or if the knowledge of etiology excluded other causes. Its prevalence is rather in periods of rapid growth, and, as a rule, severe scoliosis originates before school-days commence. Long sitting and want of exercise obviously are contributory causes to any deformity from asymmetry. Kirsch, of Magdeburg, has shewn the large part rickets plays (*Deut. Med. Woch.*, 1908. ii. 30). Several recent German writers hold that neither school nor writing habits can be accepted as the cause. The discussion in 1910 at the German Orthopædic

Association disposed of the school theory. Schultess, of Zurich, takes it that scoliosis is the only form of spinal curvature that can be considered a school effect.

Kirsch, who started an enquiry in 1905 for long-continued observation of the same children in Magdeburg, found the proportions of different varieties in 1015 children as first grade 17·6 per cent., second grade 4·5 per cent., third grade 3·5 per cent. (*Gesund. Jugend.*, viii. 136).

Many years ago, Gould, the Philadelphia ophthalmologist, attributed curvatures largely to differences in the eyes (*Ophthal-*

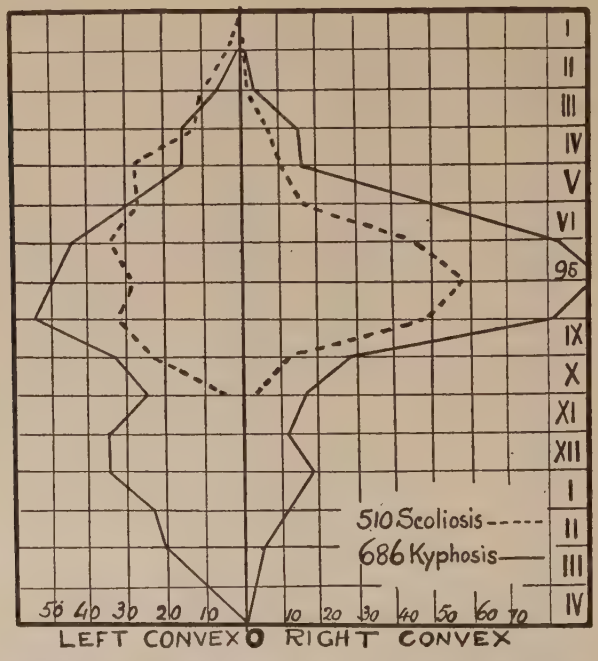


FIG. 38.—DISTRIBUTION OF POSITION OF GREATEST CURVATURE IN SCOLIOSIS (DURRER) AND KYPHOSIS (SCHULTESS).

mology, 1904). Wilson (*New York Med. Journ.*, 1906. 157) attempts to bring out head tilting as an etiological factor, but his conclusions are very uncertain. Dr. Mina Dobbie assessed the spinal condition of 731 boys and girls, aged 12–13, in London primary schools. After this had been done, the vision records were taken out from the ordinary medical inspection cards. There was no significant defective of visual acuity, in fact the proportions with good vision were higher among those with spinal curvatures.

Scoliosis and myopia may have a common factor in postural reflexes, if ciliary spasm be regarded as a contributory factor in the development of myopia, but eye defect does not appear strongly in this regard. One would scarcely expect it, as there are many

cases with serious monocular defect without spinal changes, and, indeed, most people fix with one eye, without any spinal results.

School Treatment of Spinal Curvature.—The majority of children with spinal deviations require some relief from school pressure, and probably also require special attention from the point of nutrition. They should in all cases have in school at least a pint of unheated milk daily as fresh as can be got. Feeding is a matter

TABLE 46.

The visual condition taken from the medical inspection cards of 731 London primary school children, aged 12–13, and arranged in groups according to spinal condition. Vision groups are: good, $\frac{6}{6}$; fair, $\frac{6}{9}$ and $\frac{6}{12}$; bad, $\frac{6}{18}$ or worse. Also unequal vision. (Dr. Mina Dobbie.)

Vision	Number.	Good.	Fair.	Bad.	Unequal.
Kyphosis, Lordosis.					
Boys	29	20	4	2	3
Girls	40	17	18	4	1
Totals	69	37	22	6	4
Lateral Curves.					
Boys	222	137	41	8	36
Girls	211	96	85	8	22
Totals	433	233	126	16	58
Totals, all curvatures..	502	270	148	22	62
Percentages	68·5	54	30	4	12
Normal Spines.					
Boys	129	62	41	3	23
Girls	100	32	38	9	21
Totals	229	94	79	12	44
Percentages	31	41	34	5	19

of prime importance, and periodic rests. Each of these children should have eleven or twelve hours in bed. It is improbable that many will have a bedroom to themselves, but this also is a point worth suggesting. Sunshine and open air, indeed every hygienic advantage possible should be given them.

The school cases which benefit most from school exercises are those with deficient chest expansion. They belong, often, to the large class of unexercised children who, for want of stimulation of respiration and circulation, are soft and undeveloped. Another class is, with lack of respiratory capacity, often associated with adenoids, hypertrophic rhinitis, or other causes of nasal obstruction.

The child with round back is also likely to get good benefit from postural training.

So far as children with spinal disorder in the special school are concerned, as about nine-tenths of their number are of tubercular origin, corrective spinal exercises are more likely to be harmful than good. In the severe cases of scoliosis aggravated during rapid growth any out-patient treatment is unsatisfactory. They belong to a residential invalid school class. Wohrizek of Prague (*Zeit. f. S.*, 1907. 175) reviewed the children in that city and found 26 per cent. with spinal deviations, and suggested that 4 per cent. of all should be in a scoliotic school for special feeding, rest, and postural exercises.

Elmslie from his great experience thinks that that postural treatment is efficacious for the majority (*School Hygiene*, 1914). It can be carried out by well-trained teachers, with the children in classes not exceeding a dozen. Apparatus is needed, including for a class six ribstools, a double boom, and two reversible benches. Where individual treatment is necessary the classes should be half the size, and do set exercises, whilst each child is taken individually. A high and low plinth and vertical bars will also be required.

Structural cases cannot be satisfactorily treated in these school clinics. They need over-correcting forcibly, and then having support applied in the over-corrected position, but this is work for the specialist in the orthopædic clinic.

For school treatment, looking to the difficulty of taking pressure off the yielding spine during exercise, to strengthen the muscles and re-educate the undeveloped or failing postural reflexes, Klapp suggested that crawling on all fours would be a useful attitude. The spine could be exercised, and by different kinds of crawling, alternate sides or the same side, hand and foot, the curvatures could be modified. These exercises had much vogue in Germany before the War. It is doubtful whether they were worth the trouble. The treatment is simple, it is not costly, and it is accessible to large numbers of children, but it is also doubtful whether the accessory feeding and resting from school work has not a very great deal to do with the result, apart from the crawling.

In any case, it is to be expected that it should be more efficacious the younger the child.

Frank, who observed the children in the Mainz scoliosis school (*Zeit. f. S.*, 1907. 433), thought the method only useful in slight cases, in some it was even harmful. The child had to attend for months, or even years. Hartel describes the Bonn classes (*Gesund. Jugend.*, vi. 145). He approves of it as a natural method, and thinks the results good. The children attend twice daily. They are rested for 20 minutes with their backs to a Bier's hot-water apparatus to induce some spinal hyperæmia. Crawling exercises, chiefly in small

circles, bringing the hand and knee as close together, or overlapping on the same side as the convexity of the spine to correct the spinal curve go on for the greater part of an hour. They wear list slippers, leather-protected knee-caps, and stout gloves. They are then each given a pint of milk, and are supposed to rest horizontally for an hour.

It is probable that these classes have a limited application, but it is not likely that the method will ever be extensively applied in England. At the same time the intensive hygienic treatment of rest and feeding should be used, whatever the system of exercise.

As regards school as a general cause of spinal deviation, this is only to be considered as a product of fatigued muscles, and counteracted by rest and play. The English school-room in its restricted space practically compels long hours of desk work, the children are crowded together in desks which are too narrow, and the school work allows scarcely any movements in the course of lessons. This scanty floor space is the chief factor in school aggravating spinal curvature.

CHAPTER XI

THE FOOT

Those who work in schools frequently have their attention drawn to foot troubles in children, or sometimes in teachers. There are weak feet, flat feet, painful, cold, damp, or even offensive feet. These are the common topics which the school doctor has to consider rather than more uncommon deformities or diseases for which orthopædic text-books must be consulted.

Children have enormous powers of adaptation, and also great range of physiological variation, and the majority of children of eleven or twelve who have defects of feet or spine have these as developmental irregularities, which if given reasonable chance turn out functionally all right. The school may destroy these chances, so the part which it plays must be carefully considered.

The comparative anatomist sees a common plan in the development of the limbs, and notes that the human foot represents the whole structures commonly called the leg in the horse. The foot is part of the adaptation for upright walking. Whilst in the horse the other toes are almost suppressed and only the middle toe developed, with the nail as a hoof, in the human foot the great toe develops and is of great importance. Professor Humphry of Cambridge used to say that human beings had raised themselves to the upright position on their great toes. The great toe is unopposable to the others, unlike the monkey's, in which it is as opposable as the thumb, so that these are spoken of as quadrumana.

The weight of the body falls on the articular surface of the astragalus somewhat to the inner side, it bears the articular arch formed by the lower ends of the tibia and fibula. The weight is distributed through the foot, which is plantigrade in that both heel and toe take the weight. The engineering of the foot bones shews in a section by the latticed arrangement of the trabeculæ for transmitting the weight downwards to the heel, and forwards through the head of the astragalus to the front of the foot giving lightness with strength.

Experimental evidence has been adduced to shew that in standing an average of about two-thirds of the body weight comes on the heels and about one-third goes forward to the ball of the foot.

The feet should be symmetrical with respect to the weight transmitted, and even in considering foot-gear it is the pair of boots that has to be symmetrical, not the single one.

The weight distribution is constantly varying. Every movement of a hand, every turn of the head, varies the amount and direction. If steady strain or pressure comes on ligaments they soon yield, but varied tensions and pressures are firmly resisted, and the ligaments rather tend to develop. They are the first line of support to resist momentarily any sudden changes. When the muscles fail and the ligaments are the last line of support they soon yield. The astragalus bears the weight mainly in its two directions, the greater part to the heel through the os calcis and about a third forward through the head to the scaphoid.

The formation of the foot with a long, powerful inner arch, and a subsidiary cross arch, makes it at once adaptable and elastic

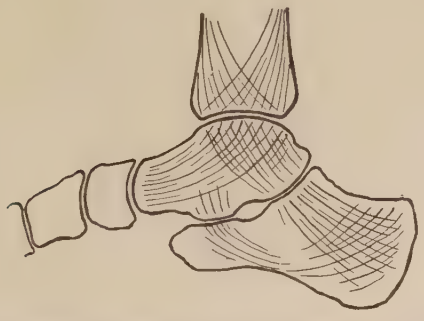


Fig. 39.—ARCH OF ANKLE, AND LATTICE STRUCTURE OF BONY TRABECULÆ SHEWN IN SECTION, AS BEARING LINES OF PRESSURE.

in its support of the astragalus. Just as the physicist uses three adjustable points to steady and level his instruments, so the foot adjusts and bears its load by main pressures on the heel and on the heads of the metatarsal bones of the big and little toes. The sole of the foot has thick skin bound by partitions of fibrous tissue to the bones and ligaments beneath, and with the interstices filled with fat. The fat baby foot for this reason looks flat-footed, but if the baby wastes the bony arches of its feet soon shew.

There is a weak place in the arch, where the astragalus head bears the weight forward to the scaphoid, and in the position of standing with turned-out toes this is especially weak, as the scaphoid is rotated downwards, and the ligament uniting it to the os calcis relaxed, allowing the head of the astragalus, beneath which it passes, to sag a little inwards. In this position it has the greatest tendency to sink. Whenever in walking there is any tendency of the inner ankle to sag there is always the potentiality of a weak foot.

If the muscles are strong and healthy, with good nervous tone,

they will bear up the head of the astragalus, but if from anæmia or other debility the postural tone of the muscles is weakened the weight of the body tends to displace the head of the astragalus inward, the os calcis moving correspondingly outward, the two sliding on their oblique joint.

The postural tone of the muscles maintains adduction and inversion of the foot against the tendency to passive abduction and eversion by the body weight. If the toes are kept straight or even turned in, there is no rolling of the foot, and no relaxation of the ligament to allow sagging and inward displacement of the astragalus, unless the muscular tone is very poor indeed.

Where the foot rolls inward under the body weight, unnatural pressure may come on the side of the great toe so that a bunion

Fig. 40.—OBLIQUE JOINT AND TENDONS SUPPORTING.

is the result, and if with a pointed shoe the great toe is bent outwards then the production of a bunion on the outstanding joint is almost a certainty.

The flaccid kind of person, wanting in postural tone, is also frequently troubled by chilblains, and likely to become short-sighted or round in the back, as well as to walk with turned-out toes and become flat-footed. The physiological use of the feet in walking or standing requires avoidance of this position. The anterior tibial line, a line drawn from the anterior superior spine of the ilium through the patella, should pass through the second toe; if it passes to the inner side of this in walking the foot is at a disadvantage. To turn out the toes in walking is not economical in force or space. The runner who made record time from London to Brighton in November 1924, ran with both feet quite parallel in the direction of movement. All gymnastic positions held with out-turned feet are bad from the point of view of progression, on the other hand

all exercises tending to develop the muscles of the feet are good. Grasping actions with the toes, actions of plantaris as well as calf muscles are useful. The crawling infant who has not yet fully developed its postural reflexes should not be tempted to walk. Walking will come spontaneously in due time, and when it walks it must not be told to turn out its toes. The futile persons in after life are often known by their splay-footedness. The goose-step, with pointed out and down toes, dear to the German general in pre-War days, was a most humiliating spectacle of ineffectiveness to the intelligent onlooker.

One of the best means to develop the feet is tip-toe exercise, preferably with bare feet, or as suggested by Tait McKenzie, walking with the heel just raised off the ground as if it were painful. Heel

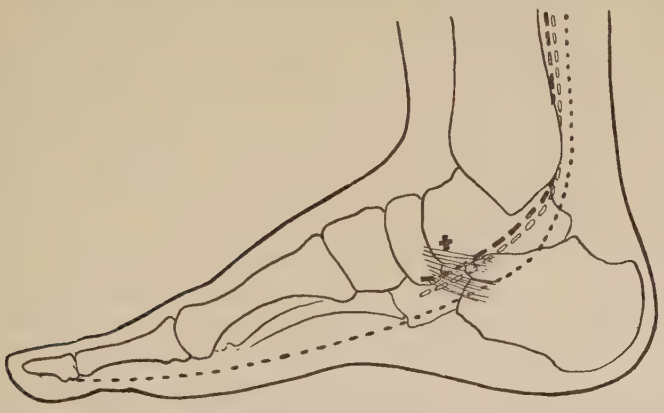


FIG. 41.—TENDONS ON INNER SIDE OF FOOT, SUPPORTING ARCH AND HEAD OF ASTRAGALUS.

and toe walking is suggested by Sir Robert Jones as holding its own remedy ; skipping, especially with bare feet ; swimming also is a good treatment for all postural defects. Tip-toe work on the stairs, crossing rooms, and so on is a recommendable practice for school-children.

The majority of people who are passed in the street appear to walk with their feet fairly parallel. The person who walks with toes turned out has to put the toe down first and thereby loses elasticity. Most people put the heel down first, then the weight rests on the outer edge of the foot, and when the next step is taken the weight passes to the front of the foot, which acts as a lever, using the big toe to push off. Elmslie, who describes the process of walking, analysed by the kinema, in *St. Bart. Hosp. Journ.* (September 1920), states that this push-off with the toe is a very important action, as shewn by the difficulties of a patient unable to use his toes. The description of marching given in the official syllabus

of exercises for schools that the head and body must be kept erect and the foot carried straight forward is unfortunately illustrated by a little girl having toes turned outwards in a way that conduces to flat-footedness. For covering ground this drill method, which is wrong, can have no comparison with the somewhat forward lean of the natural walker who goes along with feet parallel or even tending a little inwards.

The angle of gait in walking has been studied by Stanley Dougan (*Physical Anthropometry*, 1924. 275) by walking men, 126 Stanford undergraduates, and 103 High School boys, in hobnailed boots over a platform laid with carbon tissue having paper beneath. The surface was 18 by 4 ft., and they did not know the purpose of the test. The angle of the median line of the foot with the axis of the direction walked was taken for three successive steps on each side. There is great disparity on the two sides. Only six had equal angles, and only one walked without deflection of the feet. Very few toed in on both sides, although a few toed in on one side and out on the other. The greatest angle was 20·3 degrees on the right and 16·5 degrees on the left. The largest negative angle (in), 5·8 degrees on right and left 6·0 degrees. The men averaged 1·1 degrees more than the boys. The flat-footed had the largest angles.

The postural reflexes which cause the muscle tendons to hold up the arches of the feet are not very liable to fatigue, but young children or debilitated people, from too long walking or too continuous standing, and also through any causes of tenderness or pain about the feet, may tire out the reflex so that functional failure follows. It sometimes happens to debilitated children on a school journey, or even in adults who are out of tone from want of exercise or during a convalescence. In children it is rarely painful, but actual pain is not uncommon in adults. Keith suggests that it represents a degradation of function reverting from the human to the condition of the ape foot. Bankart supports re-education of the reflex by standing with the feet together, and then sharply inverting them so as to stand on their outer border. This he considers the only exercise necessary, and it has to be done frequently, and continued for a considerable time. Any further exercise is got by walking with a spring in the gait when using properly fitting boots (*Lancet*, 1923. ii. 799).

The effect of shoes which cramp development, whether tight boots or rigid clogs, in the long run weakens the muscles. Children's feet require much notice in clog districts, as in many parts of Lancashire. Corbett collected statistics there in 1919 (Report, p. 24) shewing that weak feet of all kinds were about 30 per cent. commoner in the clog wearers. Shoes are evenly worn in about 80 per cent. of children, but about 12 per cent. shew heels rolled inwards, to judge from their wear, this being commoner among girls than boys.

Obviously the great fundamental cause is that ligaments and tendons do not maintain the position of the astragalus head. The tendons should counteract the body weight which would abduct and evert the foot, their action, therefore, would be to adduct and invert it, preventing it rolling over under the transmitted weight. The failure of postural support from the muscles may be because they are enfeebled as in anæmia, debility, invalidism or from too rapid growth ; or else from their being taken at a disadvantage as when the toes are turned out.

If the great toe falls on the outer side of the anterior tibial line already mentioned the foot is pronated, and the variation from the normal weight-bearing line is the beginning of troubles.

Foot strain is shewn by tender points on pressure. These points may be at the internal lateral ligament, just below the inner malleolus, the calcaneo-scaphoid ligament, the attachment of the plantar fascia, at the os calcis, and at points of the periosteum. Tenderness, if carefully sought for, can be found in perhaps 10 per cent. of the feet tested.

Pain in the feet of children must always first suggest the possibility of tubercle, and until that is definitely excluded other foot troubles are of secondary importance. The general posture of the child is of value, but about three-quarters have bad postures. A flat-footed child may become pigeon-toed, turning its feet in to relieve pain on the inner side of the foot. The position is to some extent a natural cure.

The occurrence of hallux valgus, bending outwards of the great toe, indicates a weak anterior arch ; and two-thirds of the cases have faulty weight-bearing lines in their feet. The muscles, peroneus longus and tibialis anticus, which control the postural position of the great toe react to any stimuli from the ball of the toe, and their mechanism can be easily upset, so that traumatism apart from badly shaped boots may account for some of these defects of the great toe. Its normal position is very variable. Its axis may be parallel to or at any angle between the two directional lines drawn along the sides of the foot.

Foot strain may occur with a high arch, but when indicated by eversion and by tender points on the foot is likely to eventuate in yielding of the arch. The lever of the foot, so useful in stepping off, is being broken up, the main joint of the foot giving. The first evidence is a sagging of the inner side.

The sagging can be estimated from the position of the scaphoid. A line can be drawn from the posterior inferior aspect of the internal malleolus to the first metatarsal joint on its plantar aspect. This is the Feiss line. The scaphoid in the normal adult foot is half an inch below this line, but varies with age. The child of five should have the scaphoid a quarter of an inch below, from seven to nine

it is three-eighths below, and from ten to thirteen reaches the half-inch. Any marked variation from this is abnormal.

The deformity in the foot also shews when the foot is looked at from behind, the axis of the leg being abruptly bent out at the ankle-joint, by 10 to 20 degrees. This is very noticeable in many individuals with high heels as they walk along in their daily life.

There are congenital forms of flat or deformed feet, but beyond naming them, they need not be described for school purposes.

The lateral deformities are pes varus, adduction of the forefoot with rolling in; and pes valgus, abduction of forefoot and rolling out. Antero-posterior deformities are pes equinus, when the foot is dropped; and pes calcaneus, when the foot is raised. When the forefoot is dropped at the midtarsal joints with elevation of the arch it is pes cavus. There may be combinations. Valgus deformities are more disabling than varus. The commonest variety is the congenital clubfoot or congenital equinovarus.

The functional varieties with which the school is mostly concerned depend much on temperament, occupation, inertia, or fatigue as affecting the nervous condition of the postural reflexes. These conditions, too, often have vasomotor accompaniments in flushings or even chilblains. Sometimes there appears want of proper development in children, but this may be the result of ill-fitting boots, or even continuous heavy work in bare feet. The cramping effect of clogs has been noticed, and Muskat in Germany called attention to the frequency of this ill development as a result of out-of-school work.

With the tendo Achillis bent outward from the ankle, and the inner malleolus too prominent, the shoulder will be generally found higher on the side of the weaker foot.

In children after the age of four or five, foot imprints may be useful records. For school purposes Dr. Corbett, in Lancashire, studied simplicity by making the child wet the soles of its feet and then stand on a blackboard. The imprints may be taken on blotting-paper, and made permanent if the sole is first moistened with a mixture of equal parts of spirit and tincture of ferric chloride, with a little glycerine. An imprint is taken, and this print then treated with a solution of gallic acid in spirit, when a permanent black record will result. When the imprint is being taken a vertically held pencil is run round the foot to record its contour.

The pedographs thus obtained tell their own story.

At the Dresden Exhibition of Hygiene in 1912 a study of the evil effects of flat-foot shewed that the rejections of recruits for this cause in the previous decennium had amounted to 25 per cent. in the German army, 33 per cent. in Switzerland, 7·5 per cent. in France, about 6 per cent. in England, and in Austria from 20 to 30 per cent. according to race.

In London schools Hawkes distinguished weak feet when the foot was slightly everted but returned to the normal at rest, and true flat-foot where the whole inner border touched the ground. He concluded that the sexes were equally affected, that the condition was more marked in periods of rapid growth, and was commoner with malnutrition. He thought that slight and curable cases might easily become permanent (*L.C.C. M.O. Ed.*, 1910. 135).

It is quite possible that these functional cases shew more in the period of rapid growth in height, as in the spring months. In a very poor East End school of about 900 children Hawkes found weak or flat feet in 75 per cent. of the boys and 63 per cent. of the girls.

Clement Dukes noted at the entrance inspection 325 among 1000 Rugby boys were flat-footed, and many with chilblains.

Ward Crampton examined over 2000 pupils in New York high schools, finding 32 per cent. presenting weak feet and in addition

Fig. 42.—PEDOGRAPHS OF NORMAL, OVER-ARCHED, AND FLAT-FOOT.

12 per cent. with broken-down arches. As the proportion varies with age and sex this statement may not be sufficient, but a very detailed account of the frequency of all the signs and symptoms in school is given by L. T. Brown (Buffalo Congress, v. 10).

The pedograph does not give the whole story as there are many persons flat-footed in this sense whose feet are painless and efficient. Many of these, however, have no reserve, so that on a walking holiday, or as exemplified in the War by marching, they easily break down.

Whilst skipping or running about or dancing with bare feet are all useful, flat-footedness is not uncommon among the barefooted in holiday camps. Barefootedness is preferable on health grounds to cramping a child's foot into rigid tight shoes, or boots half-way up the leg restricting ankle movements. The question does not

arise in England, but abroad, as in the Transvaal, Leipoldt draws attention to the risk of infection with bare feet, as for instance bilharziasis.

Barefoot dancing or drills, especially where suitable gymnastic shoes are not provided, have many advantages for strengthening the feet and developing them. Disadvantages suggested are splinters from floors, but in actual practice they have not been reported. The writer first attended a Scottish village school where half the children were barefooted, without any obvious disadvantage. The delicacy of the feet of Europeans compared with Arabs has been mentioned by writers as shewn by easy failure of circulation and inability to withstand cold.

Cold feet in school have indirect effects in discomfort, and resulting efforts at relief. They also cause secondary congestions of nasal and aural surfaces. They are not uncommon, possibly due to debility, and many who suffer have also a liability to chilblains. A few may be the result of improper seating restricting circulation by popliteal pressure, or possibly to constriction of elastic garters, congested cold feet resulting.

Chronic coldness may also be due to hyperidrosis, said to be relieved by occasional daily use of a lotion of equal parts of aqueous formalin and alcohol.

For the offensive feet which some children have, in spite of frequent washings, the best remedy is the free use of dry boracic powder about the toes and in the stockings.

Shoes for children should be supple and elastic ; heavy boots are inadvisable. For anyone high heels throw more weight on the arch, the range of the calf muscle is lessened, and indeed all the muscles maintaining the erect posture are strained, some unduly contracted, so that they are easily muscle-bound and affected with myalgia. The tilt downwards of the feet necessitates compensatory spinal and abdominal postures being assumed, corsets have to be worn and there is a loss of spring. The wearer becomes digitigrade and Röntgen rays shew the flat arch of the foot in such a shoe. The foot becomes almost functionless as an aid to walking, the individual walking on the flat with the elasticity of a man with two peg legs, and having increased difficulties in going up or down a slope. Where one foot is more affected than the other, or from pain or strain efforts made to save it, compensatory spinal changes may occur, and this is a cause of scoliosis always to be looked for in children.

Young teachers who take little exercise sometimes complain of foot pains suggestive of flat-footedness. Tubercle has to be thought of in these cases, but if excluded moderate exercise, tip-toe exercises, and swimming may be recommended.

In older teachers with pains in the feet rheumatism must be

considered. Rheumatism is sometimes suspected, however, in hip or knee when painful strain results from flat-footedness. Pain about the heel and under the heel may often be a sign of a septic focus somewnere, such as may occur with pyorrhœa, septic tonsils, or nasal troubles. Here again the attitudes of standing and walking are useful, and the pedograph will help in a decision.

Long standing may break down the postural tone by fatigue, and perhaps this is one of the commonest beginnings of flat-foot in adults.

A case like this in a teacher, however, should be seen by an orthopædic surgeon, as many in middle life scarcely improve without the help of properly adapted supports.

CHAPTER XII

CRIPPLES

The Cripple Child.—When the Spaniards under Hernando Cortez overran Mexico in 1518, they found in Tenochtitlan, the capital of the Incas, the first cripple school.

Little appears to have been done in Europe beyond one or two small charities in England and elsewhere. Copenhagen realized the public duty in 1870, and started special schools. As to America, Dr. Ewarhardt wrote (*Am Phys. Ed. Rev.*, 1914. 564): "As near as I can determine, only a small percentage of the thousands of crippled children receive some meagre kind of an education; the majority grow up gathering a bit of learning here and there, and continue a burden on the family or State, with little chance of making a decent livelihood."

The Education Act of 1870 discovered sections of childhood who did not fit the ordinary elementary school, and in 1893 an Act provided for Blind and Deaf. Before this the School Board for London took action about 1890, and in 1896 stimulated the Central Authority to appoint a Departmental Committee.

Mrs. Humphry Ward got the London School Board to provide an invalid school for day pupils at her Tavistock Place Settlement in 1890 (*S.H.*, 1920. 97), and thus inaugurated the whole movement.

The Elementary Education (D. and E.) Act of 1899 enabled the Local Education Authority to provide special schooling, and in 1901 three centres, and in 1902 four centres, were opened. Under an active Medical Department of the School Board, which now came into existence, these expanded, and reacted on surgical practice.

The first hospital school started at the Orthopædic Hospital in 1904, and the day school for tuberculous children at Kensal House was opened in 1910. Education Acts in 1914 and 1918, carried out in the Education Act 1921, put a statutory duty on the Education Authority of seeking out and caring for Physically Defective Children.

In earlier years there was a tendency of authorities to look on education in the ordinary school subjects as all, and to send the children out at sixteen to sink or swim in life.

Mrs. Kimmins in 1904, with her residential cripple schools at Chailey, taking "*Lætus sorte mea*" as their motto, tried to teach cripples to become self-supporting, independent units of the com-

munity. The great success of her example was soon followed by Sir William Treloar's Cripples' College at Alton.

School discrimination of physically defective has to be made on the certificate of a medical officer approved by the Board of Education. A child may not be admitted to a special school before 2 years of age. The parents are compelled to secure education for a physically defective child over 7 years old, and if required must submit the child for examination. The period of compulsory education is till 16 years of age. The parent is liable to contribute a proportion of any cost over provision for elementary education. This would include contributions to cost of guides or transportation, feeding, or medical treatment.

Adequate provision has to be made for subsequent examination of the children by a medical practitioner possessing special experience of the particular defect from which the child suffers. The child must be medically examined at least once a year as to its physical and educational progress, and if the parent desires it, must be re-examined at the end of six months.

Numbers of cripples vary. The first surveys made differed enormously. Shropshire, well organized as regards orthopædic care, returned 19·9 per 1000; London, 13·9; Lancashire, 5·9; and Birmingham, 5·8; although all were probably about the same figure in reality.

The numbers requiring special provision in any extensive section of the school population will not vary much from 1 per cent. The Minister of Education stated in March 1925 that there were 34,591 non-tubercular crippled children and 49,358 delicate children, and the special provision existing was for 2759 in Hospital Schools, 6386 in Cripple Schools, and 4690 in Open-air Schools.

The causes of crippling may be set down as found from school reports. In Elmslie's 1922 survey of London school cripples, the causes ascribed were: Infantile paralysis, 961 (41 per cent.); Tuberculosis, 732 (32 per cent.); Congenital causes, 180 (8 per cent.); and various other deformities, 421 (18 per cent.), in a total of 2294 (100 per cent.).

Hospital cases shew differently, as some being chronic and permanent disappear from notice. Dr. Wheatley gives for Shropshire Orthopædic Hospital in 1922; Tuberculosis, 40·8; Poliomyelitis, 12·1; Accidents, 11·2; Various, 31.

Preventive Treatment.—The main causes, in which preventive medicine should take an important part, are poliomyelitis and tuberculosis, of which crippling Elmslie shews 84 per cent. as originating before school age is reached.

This is set out in the figure, as poliomyelitis 96, tuberculous disease 70 per cent. before pre-school age is past. This is, therefore, the time for influencing the prevention of four out of five of these

cripple cases. It should be the duty of the Education Authority to extend its survey and care to these ages.

Neglect of infant palsy in this country is grievous. The greater part of the paralysis could be prevented by early care, which at present is beyond attainment by few except the richest members of the community. It is worth spending very considerable sums on a

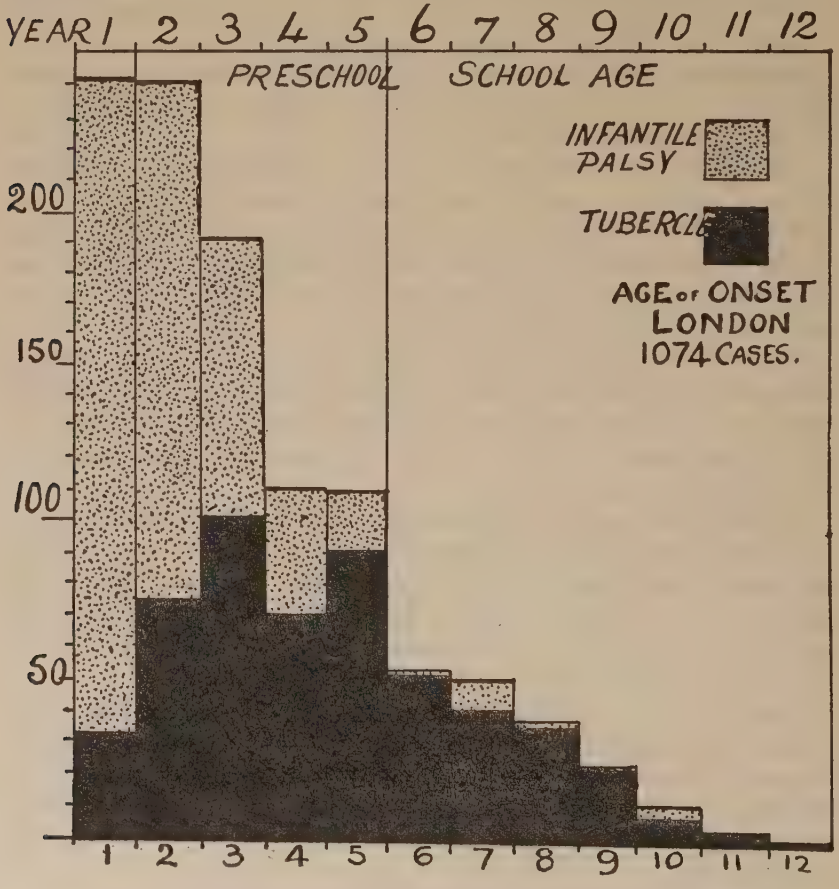


FIG. 43.—ONSET OF CRIPPLING IN PRE-SCHOOL AGES.

rapid and effective provision for any outbreak by despatching units from the Central Authority to any part of the country to undertake care of even a few cases, till the danger is past. Such a unit would include doctor, nurses, and other workers, with outfit.

Plymouth has suffered severely. "The result of the outbreak of 1911 is still seen in 88 cases of children now paralysed, 24 in both legs, 21 in one leg, 37 foot, and 6 arm cases" (*Report C.C.C. for Cripples*, 1922).

Every case of infantile palsy wants prolonged attention. When

the acute danger is past, every case requires at least six months unremitting care, and many will need a couple of years' hospital stay and training.

It will cost less to the community than the present method of awaiting the maximum damage before attempting to relieve it.

Discrimination and treatment of these cases is so much an expert practice that they will not be dealt with here. Rest, surgical relief, and heliotherapy are the chief means.

Actual crippling means, in many, conveyance to school. Physical treatment in the day school by massage or curative exercises Elmslie holds unjustifiable, except in a clinic.

In many clinics treatment goes on for cases which are fixed and permanent, wasting time and cost. Even in the residential school, surgical treatment by operation is out of place, the cost of the outfit being beyond measure for the numbers needing it. All surgery should be reserved for the hospital.

Cripple Classes.—The school nurse has the oversight and responsibility for the children's health and their orthopædic care in school. It does not pay to admit any advanced tuberculous case, even on probation. No child in a day school should have open wounds or sinuses or need dressings changing. The unexpected is always possible, and the nurse must be alert for events. For instance, a boy who had been playing active games, almost accidentally was found with a large fluctuating psoas abscess just pointing.

Cases of paralysis vary educationally. Spastic cases due to cerebral causes generally suffer in mentality. As a rule hemiplegics are best mentally. Diplegic or paraplegic cases are almost always of subnormal mentality. Apart from mental defect, there is a general agreement that physically defective children, tuberculous, paralysed, and deformed are all mentally retarded ; even rickets gives some mental retardation.

The average of 100 cases tested by Dr. Wyche gave I.Q. 88, and tests at Tavistock Place centre gave 133 out of 152 as below average school mentality.

Much of this is real defect, in spastic palsy cases for instance. The greater part of it is educational defect, from want of experience and opportunity, and may be expected to be overcome in time.

The crippled child is often self-commiserative and turns its disadvantages to profit, as a means of getting its own way in everything. To combat this tendency Mrs. Kimmins insisted at Chailey that each child should be treated as to conduct and behaviour as if normal in all respects. Contact with a world of cripples adjusts social levels, and makes the individual put forth efforts that he has hitherto been prevented from making. So long as he is among other cripples, there is no sense of inferiority in competition, rather does he develop self-reliance and ambition. It is difficult to realize

the restrictions, the poor muscular sense, and almost chronic fatigue of some of these cases. Many require attention to speech training, and a few have weak visual accommodation. Cut off from the illuminating life of the streets, and much natural education, the cripple school opens a new door. For a few it is mainly a shelter ; for instance, the boys who suffer from the progressive pseudo-hypertrophic palsy. They are happy in school, and as long as they can manage should be allowed to attend. The progress of disease means that they are likely to become bed-ridden before school age is over.

All rooms are to be ground-floor. They should be well lighted, and require to provide 20 sq. ft. of floor space per head. Chairs and tables and adaptable chairs and seats are required. The desk should have positive and negative movement horizontally, and also vertical adjustment.

Ilkley couches with the centre adjustable are useful for recumbent cases.

The great need now being met is a comprehensive scheme which by co-ordinating various agencies will take charge of the cripple, from the first beginning of trouble in the form of a pain or a limp, till he becomes an independent worker. The greater number of cripples are made, not born, and many have serious relapses for want of care.

Orthopædic Treatment.—Hospital treatment for tuberculous disease formerly gave very bad results. Immediate relief of urgent symptoms was all that was possible. " The usual Hospital method of treating such cases can never be efficient " (*L.C.C. Report*, 1907. 48). The hospital school of recovery, instituted at the Chailey Schools about this time, has been followed by a counterpart in most schemes. Residence may have to be very prolonged. According to Alton experience radical methods of treatment are fatal compared with conservative methods. But this means prolonged treatment.

In Liverpool in 1921, bone or joint cases were in-patients from 228 to 1276 days, averaging 574. Abdominal cases average 252, other organs 246, and peripheral glands 183 days. The success of this was measured by 83 per cent. discharged quiescent.

There is no section of social care in which voluntary effort has done more for the relief of the effects of poliomyelitis than the Invalid Children's Aid Association, but their efforts are partial. Miss Champness, whose untiring work started the Cripple Association at Plymouth, records the great handicap of poverty in dealing with poliomyelitis. " Where money can be spent, you get progress and cure, but in the slum it means life at a dog's level." Charity and voluntary work is therefore insufficient. A public organization is needed.

The clinic and hospital and school course must be followed by

some kind of vocational training. These arrangements lie with the administrative side of education.

Vocational training of cripples must be begun early. Handwork is the best. The London Schools give their afternoons to manual work. It should be adapted to children starting in employment. Embroidery and sewing, lacemaking, are occupations girls can easily learn. Boys at Chailey mostly do cabinet-making. Tailoring, shoemaking, carpentry, and, for weaker children, basketry or bookbinding, are useful. Some may attain to fine metal-work, such as jewellery, watchmaking, delicate locks and keys. The training should not be too specialized, but must be thoroughly practical, and aim at turning out pupils who can make or do something for their living.

The principle of physiological rest advocated by Dr. W. Mackenzie of Melbourne (*B.M.J.*, 1915. i.) has to be remembered, as it involves rest in a fixed bed splint, to rest spine and limbs, from the first days of attack, and then residential treatment for months, if paralysis is to be avoided.

In New York in the 1916 epidemic of 8927 cases, the home cases had a mortality of 64 per cent., the hospital cases 15 per cent. Selection would come in here, as many cases seen would be too bad to be removed. Seventy-five to 80 per cent. of persistent paralysis fell upon the class of people who usually obtain medical services free (*Pediatrics*, November 1916).

The school doctor must, therefore, strive his utmost to bring this disease into the scheme in its earliest onset.

Lovett, after watching the results for three years, thought the abdominal muscles had the smallest chance of recovery, and then chances of recovery diminished in the muscles with descent to the foot, owing to premature use in the healing process (*J.A.M.A.*, 1921. ii. 1941).

The proportion of children seriously damaged by disease or surgery is diminishing remarkably. One never sees a circle of wheeled chairs as formerly, and may hope for the day when crutches will also be as rare. There is no corner in preventive medicine in which the progress is so obvious and evident.

Many cases become able to return to the ordinary school. In Aberdeen most of the children with the results of infantile palsy, or recovered from tuberculosis, are kept in the primary schools. Only when crutches or orthopædic appliances prevent this is a child sent to the special school. No physical harm has come to any of these children, and they appear to benefit in every way by being treated as normal. Only 9 out of 26,000 children on the rolls are in the special school.

CHAPTER XIII

SEATS AND DESKS

Whilst during its first three or four years of life the alimentary and nutritive functions almost entirely overshadow others, these aspects relatively lessen, although for the next decade they still play a very large rôle in child-life. Through the whole of school-life, perhaps rising to a peak between seven and ten years of life, the motor side of mental action is in the ascendant. There is need for a rhythm of intermittent but violent muscular exercise alternating with rest periods. Much scope is wanted for all kinds of play. For young children long waking periods unrelieved by sleep mean under-nutrition and fatigue, and every child below the lower standards requires from one to one and a half hours' early afternoon repose, preferably lying asleep.

Existing Furniture.—The work of the elementary school being still unfortunately, owing to the small class-rooms, mostly desk work, the prolonged muscular restraint is unduly exhausting for young children, and has to be regarded as a compromise between physiological needs and educational requirements. The child cannot be adapted to desks, so, as far as possible, seats and desks must be adapted to the child, and as some 20 per cent. of the whole population pass from three to five hours daily in desks, it is a subject of immense importance. Some figures noted by the writer in 1917 shewed that the main varieties used in London elementary schools were eight sizes of dual desks, the first six sizes with sloping tops, the last two flat-topped kindergarten tables. There are two varieties —A with foot rests, and D without foot rests.

The A and D patterns are 88,500 in London County Council and 36,300 in voluntary schools ; old pattern B, 128,000 in London County Council and 25,500 in Non-Provided Schools. Clarke's desks (still older), 17,250 London County Council and 4300 Non-Provided ; and Bennett desks, 29,200 London County Council. Single desks are 6600 London County Council, and 1350 Non-Provided. Locker desks, 9750 London County Council ; Sheffield desks, 14,000. In a large East End school 19 varieties of desks were measured, whilst in another school-room 13 different measurements were obtained in 24 places, and in the same school another room had all the places of the same dimensions. Probably none

of these seats and desks in themselves could reasonably be discarded, although the use of the same sizes throughout a class of varied children could be improved.

Some authorities are not so well provided; thus Kent, "the Garden of England," with many rural schools, had a survey published in his Annual Report by Dr. A. Greenwood in 1921, in which it was difficult to see that any definite scheme had been followed in providing furniture, as of 24,311 children noted 7210 (30 per cent.) were on forms without backs; 2567 (11 per cent.) on long forms with backs; 12,431 (51 per cent.) were in dual desks; and 2103 (9 per cent.) had chairs and tables.

Dimensions of Furniture.—No special regard seems to have been paid to seats and desks till the middle of last century. Mediæval representations shew, and the practice of the Church, as well as chained books of olden times, bears this out, that the reader usually stood to read the book sloped at an angle of 40 degrees, laid on a desk the lower edge of which was about the level of the upper third of the sternum.

Barnard (1838), in Connecticut, directed attention to the great importance of the horizontal relation of the seat and desk, what is now technically called *distance*, in preventing children leaning forward, and demonstrated that there should be no interval (null or zero distance), or that the desk edge should overlap the seat edge a little (minus distance), and yet the writer found a secondary school class in Leeds, sixty years later, with a positive distance of about 9 in. Bradford, about that time, from Standard I to Standard VII, had uniform seats $16\frac{3}{4}$ in. high, and a positive distance $4\frac{1}{2}$ in., and the School Board for London were having three sizes of seats and desks with a positive distance under 2 in. So slowly does knowledge diffuse. Meanwhile, steady advances were being made abroad. The first attempt to detail school furniture is in the Schaffhausen regulations (1852), as to heights and width. Then a German writer, who is usually credited as the originator of these enquiries, Fahrner, wrote in 1863 (*Jahr. f. Kinderheilkunde*, 6. 151), and his suggestions were adopted in the Bavarian Regulations (1867). Since then every conceivable arrangement and relation of seat and desk has been attempted. There were seventy varieties shewn at the Paris Exhibition of 1878. The search for the perfect desk is as vain as that for the philosopher's stone. There is no optimum desk to remedy ills and compensate for the evils of school hours. It is physiological nonsense to attempt to constrain a child to one attitude for hours daily. The weight of the limbs and the deforming effect on the skeleton leads to exhaustion of the postural muscles. The child escapes this fatigue by frequent changes of position and attitude. The fault is really time spent in desks, and the reform wanted is reform in the whole elementary school curri-

culum. The chief hindrance, however, to suitable seats and desks is the cry for cheapness and economy. Money spent here will be wisely spent. There is no national economy from cheese-paring in school-rooms or furniture. The gain has to be repaid many times over in the inefficiency of later years.

The real planning of an elementary school on the present-day lines begins with the seats and desks, and round these the class-room should be constructed.

Fahrner, who wrote first on the subject, devised a seat and desk which is possibly better than considerable numbers of those in everyday use at present.

He took the height of the seat as most suitably two-sevenths the stature, and the *difference* between the seat and desk as one-seventh the stature. He adopted the null *distance* and put the seat edge and

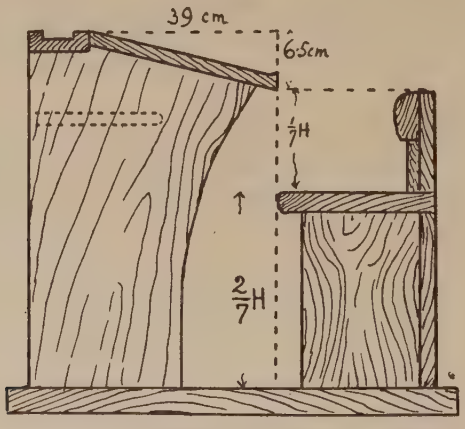


FIG. 44.—FAHRNER'S SCHOOL DESK.

edge of the desk in the same vertical plane. The desk was sloped in accord with the dimensions shown on the figure, and a back rest was placed with its top level with the desk edge.

These are approximately correct dimensions. School desks cramp and restrict the scholars, and all further variations have been attempts to remedy this, or to cheapen the provision. The old continuous desks provided in the schools of the middle of last century had long seats without backs, and generally a positive distance. The seats were usually too high and the children leant forward on the desk for support. Backs could not be provided or there was difficulty in moving the children in or out.

The general requirements of a seat and desk for school use are :

1. They should be suited in the dimensions to the size of the child.

2. They should allow the child to be in a healthy (*a*) working and writing position, (*b*) listening or reading position, (*c*) standing, supporting and relieving its muscles without straining or fatiguing, and maintaining a good position of the head and eyes in relation to work.

3. They should allow freedom of movement and change and adjustment of position rapidly and noiselessly, standing up or sitting down, going in or out of the desk.

4. Each child should be isolated as much as possible from its neighbour; the provision of sufficient space being more important than the exact model of desk.

5. They should not have any dangerous joints or hinges, to snip fingers, or knock eyes.

6. They should be strongly, simply, and inexpensively built, and without ornaments or beadings to accumulate dust or afford scope for noise.

7. They should provide a certain amount of storage room for books and school implements.

8. There should be full supervision possible without much trouble to the teacher.

Till the present generation in England, the suiting of seat heights and desks to the sizes of the children seemed quite unthought of.

TABLE 47.

HEIGHT GROUPS IN DIFFERENT STANDARDS.

(Total number of children, 1603.)

Height groups ..	.. ..	45 in.	50 in.	55 in.	
Heights in inches ..	Under 42½.	42½–47½.	47½–52½.	52½–57½.	Over 57½.
Standard I ..	37	126	11	—	—
II ..	11	162	90	6	—
III ..	2	93	184	44	—
IV ..	2	39	174	78	9
V ..	2	5	131	107	15
VI ..	—	2	56	137	20

Whole schools were fitted as in Bradford with its 16¾-in. seats. The Sheffield desks fitted during the past fifteen years in London were all of the same size in a room.

In 1893–4 the ages, standards, and heights of children were noted in Bradford Board Schools (Table 47).

This table showed that 95 per cent. of the children came within 2½ in. of the three selected groups, and seats and desks were adjusted for these groups (*J. Roy. Stat. Soc.*, 1897. 656). A dozen years later the measurements of some 8000 London children, who ranged from 104 cm. to 170 cm. in height, enabled a table to be prepared allotting the sizes of seats and desks required for each average class of 40. There is a comparatively slight difference in the case of boys and girls respectively, the elementary school girls being a trifle larger, not smaller, as usually stated; it is disregarded in Table 48.

Burgerstein introduced a school measure for desks in the form of a board on which the desk size was painted together with the

range of heights of children to use this size of desk. In our English schools each place should have a small plate indicating the height of the child who may use it. This would also interest children in their own growth.

Seats.—The height of the seat from the floor which Fahrner put as two-sevenths of the stature, is better expressed as equal to the length of the leg, when sitting with knee bent at a right angle, and measured from under the knee to the ground. This is a fundamental measure, but legs and arms are not necessarily proportional. As Stecher points out, children with 16-in. legs vary in arm length from 21 to 28 in., but the number varying more than an inch and a half from the average is small (*Am. Phys. Ed. Rev.*, 1911. 453).

TABLE 48.

ALL CHILDREN (LONDON ELEMENTARY SCHOOLS).

Desk size	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Seat height, cm.	32·5.	35·0.	37·5.	40·0.	42·5.	45·0.
Standard I	27	9	4	—	—	—
II	14	12	12	2	—	—
III	3	10	20	7	—	—
IV	—	4	21	12	3	—
V	—	—	10	22	8	—
VI	—	—	2	20	15	3
VII	—	—	2	9	18	11

If the seat is too high the child leans forward, attempting to get the toes to the ground ; if too low the knees are bent and the thighs press on the abdomen or else the body is stretched out, and the advantages of support from the feet and of good attitude are lost.

The width or depth of the seat should be determined from length of thigh (28 to 30 per cent. of the stature) ; that is, about one-fifth height, or two-thirds of the length of the femur.

The length of the seat usually is considered chiefly for the dual desk. Desing (1904) puts it as 36 cm. plus 12 for the middle part, making 2 (36 plus 12) for a dual desk. This is probably too short. Most seats err in this respect, and it would be wise to make them come within 2 or 3 in. of the desk length.

The seat should be a little hollowed, not quite flat, and, if anything, tilted a little backward, about 5 degrees with the horizontal, to prevent the tendency to slip forward. One Swiss constructor (*Grob.*, 1899) patented a seat which he called " Inklinationssitz," like the seat of a coachman, tilted to an acute angle, the weight being borne on the foot-board. A back rest is required and will be discussed later.

Desks.—The height of the desk edge above the seat edge is called the *difference*. Fahrner put it at one-eighth the stature and added 3 to 4 cm. as correction. Physiologically, it should be the elbow height, or the smallest trifle higher. It is better a little too high than too low. The child should be able to write without raising the shoulders. Cardot, from measurements of 4000 Parisian children, placed the height of the desk edge as equal to the height of the xiphoid cartilage above the seat. In practice these values have been obtained empirically.

The breadth of the desk has to be sufficient for all the exercise books and papers likely to be used. Burgerstein defines this as usefully measured by half the length of forearm and hand with outstretched fingers. Almost all authors want the desk top sloped as much as possible. Theoretically it is best. Ancient scholars were supposed to work with desks of 45 degrees' slope. Standing to read this way, as in church or the Tudor library, all parts are relatively the same distance from the eye, a distinct advantage for those who read with difficulty. A sloped desk, too, gets better window illumination, the illumination diminishing according to the cosine of the angle of incidence. Too much, however, may be made of sloping the desk, and in any case objects lie on the desk better and the ink runs off the pen better when the slope is slight, not more than 10 or 12 degrees. Most writing work out of school nowadays is probably done on level surfaces. For kindergarten desks no one thinks of sloping them, and for school work as it ought to be done, level tables would also probably be best. The writer would reject no desk for want of slope, but for writing would prefer a trifling slope under 10 degrees, to the level.

The length of the desk is of very great importance, practically every English school place is much too restricted in this regard. Schmid Monnard wanted it equal to the distance between the elbows when the arms were laid along the edge with one hand covering the other. The French Regulations say for children under 1·20 m. stature the desk must be 0·5 m.; over this height it has to be 0·6 m., but in the case of dual desks this last may be 0·55 m. The usual German measurement is five-twelfths the stature. Breslau schools which have continuous desks with chair seats allow 65 cm. (26 in.) to each chair. Glasgow fitted out its Bernard Street Open-Air School with 26-in. single desks.

Foot rests are largely used, and quite careful authors as, for instance, Dufestel, speak of them as indispensable. They may keep the feet from being cooled on the floor, and may help wet feet to dry, but they tend to fix the child in a way that is undesirable, to prevent it getting relief from frequent muscular readjustment, and the writer regards them as unphysiological, unnecessary, and costly. When foot rests are raised considerably above the floor

level, and some desks have as much as 4 to 6 in., this is equivalent, for illumination, to reducing the window height correspondingly, a needless expense. By using two extra thicknesses of wood, adjustable varying heights of foot rest are obtained in the Breslau schools.

Back Rests.—It is important that steady pressure shall not be maintained on one point; discomfort arises, the child's attention is distracted from its work, and shuffling and movement to relieve the pressure begins. Too wide or high a seat pressing unduly on the popliteal space may easily interfere with circulation, and produce cold feet or even "pins and needles." All attempts to obtain upright attitudes, for instance in vertical writing, are vain, and only endured for a few minutes. Good attitudes can only be maintained by considerable latitude in actual position and easy support of the

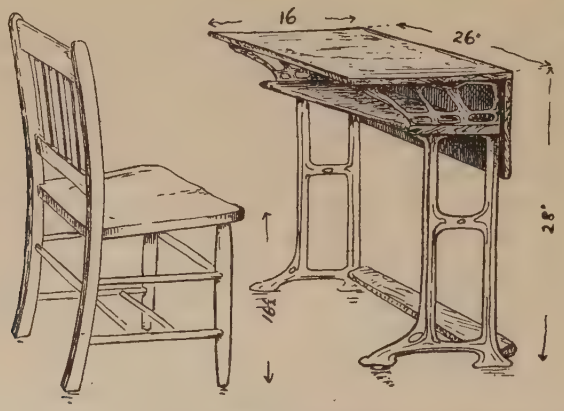


FIG. 45.—SINGLE DESKS, 26 IN. IN LENGTH, USED AT BERNARD STREET, GLASGOW.

postural muscles. Back rests are, therefore, an absolute necessity for all school seats.

On using the seat and desk there is from the maintenance of the same position over a long time a considerable tendency to fatigue the postural muscles, so that vicious attitudes are assumed. The back muscles relax and the spine with the body weight bends forwards; at the same time the weight tilts the pelvis back and the viscera are compressed and circulation and respiration hindered, whilst the head comes forward and the eyes are approximated to the work.

One may therefore sit bolt upright, in which case the tubera ischii bear the main weight, the centre of gravity falls in front of the line joining them, and support is obtained by pressure on the thighs and especially the edge of the seat helps to steady this. As the position becomes more tiring, the spinal muscles yield and part of the weight is then taken up by the arms on the desk, and now it is that the pelvis tends to tilt backwards and can be usefully supported

by a low sacral rest or low lumbar rest perhaps better. This fixes the pelvis and leaves the body and arms free for desk work.

In listening or attending to other than desk work, to relieve the spinal muscles as much as possible, the weight should be taken off in the dorsal region as well (Fig. 35). Orthopædic experts like Lorenz and Schultess (*Zeit. f. S.*, 1896. 1) advocate support for the general curve of the spine, the "Reklinationsitz," a seat back somewhat convex to about the level of a half-inch above the crest of ilium, then sloping back a few degrees so that the whole lies at a slope of 100 to 115 degrees with the seat. This should rise higher than the level of the desk edge, and extend to just below the shoulder blades. Cotton, who worked at the subject experimentally in Boston (1904), found that two sizes were sufficient for schools (*Boston School Report*, 1904). A relatively low back support he thinks ample. In the reading position no support is useful below the top of the sacrum, and below this a space should be left. In writing the body does not simply swing; there is a slight rock of the pelvis, so that the back is still in contact with the support if properly curved. He defined his largest size of support as $9\frac{1}{2}$ in. wide and 5 in. high, with a concavity from side to side of 1 in., and a convexity in profile of 1 in. The whole is tilted backwards a little. The maximum convexity he placed one-third up, and said it should come opposite the fourth lumbar vertebra. It might be suggested that if instead of the adjustment by sliding up and down it was given a slight free play, it would be a perfect form of back rest, equivalent to a good cushion which, perhaps, would be the best form. The writer's opinion is that the fourth lumbar vertebra seems the position in writing, reading, listening, or resting which alters least and where support would be most useful. Kemsies's diagrams of the spine in these positions (*Jahrb. der Schulges*, 1914. 135) agree.

In an address to the Vienna School Hygiene Association just before the War, Lorenz advocated what he called the lever support. This is a practically straight back rest movable about a transverse horizontal axis about half-way between the seat and the tips of the shoulders. The pressure of the reclining upper half of the body on this, acting round the fulcrum, causes it to also press comfortably on the sacrolumbar region. In this way is prevented the sliding forward on the seat and the gap between the seat and upper part of back rest into which the lower part of the spine sinks.

Varieties of Desks and Seats.—The old long form and desk were unsatisfactory for discipline and difficult for seating the children. Where, as in some cases, the desk was hinged along its length to give greater freedom of seating, it became a most dangerous article in school, crushing fingers easily with its weight. The next step in improvement was the provision of dual desks and seats, to take two, instead of six, seven, or eight. These children became easily

accessible to the teacher and could stand out of their places without trouble by having a gangway on each side of the desk. The front surface of the desk was utilized as a back for the child on the seat in front, and very compact furniture was thus made, although compactness is not always a hygienic advantage. In other cases the seat and desk were combined in one, so that they were easily interchangeable to other rooms.

Types of Furniture.—Various contrivances have been used to get variations in *distance*, and to allow of standing in the place ; the desk top was hinged to turn back, or the seat hinged to turn up. Both of these forms had risks of injury to the children's fingers and were abandoned. Sliding desks were also used, either the top, or the whole desk being made to slide ; and sliding seats, so that at one time there might be a considerable positive, and at another time a negative distance for work. Another form was with a fixed desk

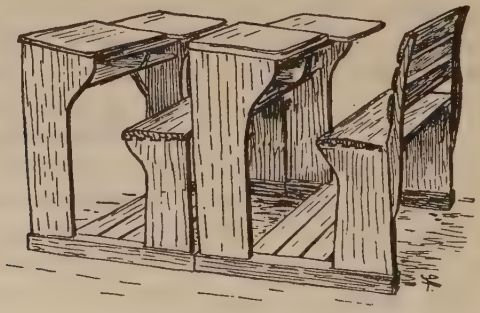


FIG. 46.—SPELLMANN'S HANOVER DESKS.

but a movable seat, which turned up and back by a pendulum weight arrangement as soon as the child stood up. All these arrangements were gradually given up for fixed seats and desks, almost on Fahrner's original model, but duals for two children. The dual desk has advantages to the person who wishes for economy at any cost. Children can be compressed on to a small area, and in some forms of desk the teachers have found that three children can be got into seats for two. They are better than long seats, but have no other recommendation than saving in cost.

One of the simplest forms is Spellmann's dual desks with a sliding top as used throughout the Hanover schools. A forty-eight room, as designed by the makers, is $5{\cdot}1 \times 9{\cdot}5$ m., giving $1{\cdot}01$ q.m., or $10\frac{3}{4}$ sq. ft. per place.

More extensively used in Central Europe are Rettig's desks, with all the parts fixed. They have seats which are perhaps too small, the back rest is too straight up, and there is a foot rest raising the child several inches from the floor. These desks have a special arrangement for tilting them over on a floor

rail so that the floor under them may be better cleaned. A forty-eight room arranged by the makers is 6·0 × 8·7 m. = 1·09 q.m., or 11·8 sq. ft. per head.

A typical London desk, known as A pattern, is of oak with metal

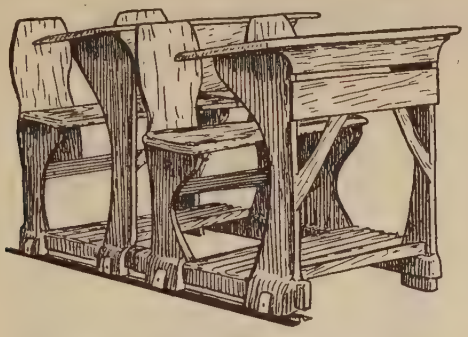


FIG. 47.—THE RETTIGBANK.

One of the most popular German desks. Can be moved and tilted on its side, on a rail, shewn black.

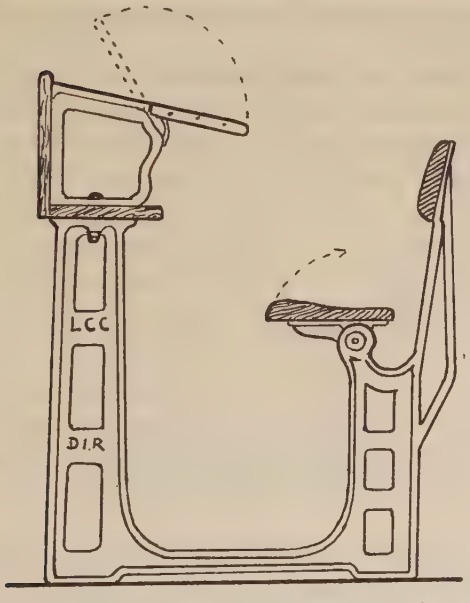


FIG. 48.—LONDON DUAL DESKS

standards. The five lower sizes, 13-in. seat and less, have zero distance; the four larger have distance increasing by ½ in. to 2 in. The lower half of the desk top is hinged to tilt up, the seat swings upwards. Foot rests are fixed on the stretchers. The older pattern, sometimes formerly called Canadian, American

or Bennett desks, was combined so that the desk carried the seat in front of it, and the series formed a train, only the front desk and the back seats being separate. Foot rests are provided. They were popular about twenty-five years ago, and are found widely used in English schools. The seats swing and the desk is hinged as in the London A desks.

The tilting seat has to be carefully examined ; one type caused

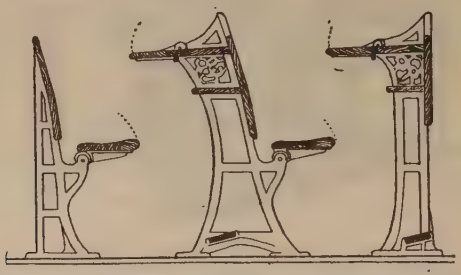


Fig. 49.—THE BENNETT OR CANADIAN TYPE OF DESKS.

dresses to be torn and fingers pinched. In four months a department with 115 of these desks and seats had 15 cases of injury, and 8 of them lost finger-nails.

Continuous Desks and Single Seats.—A continuous desk to which single pedestal seats are fitted is often referred to as the Sheffield system. This is extensively used in Yorkshire, and where intelligently placed is very advantageous, but may be as badly fitted as

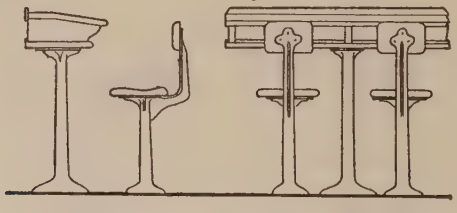


Fig. 50.—THE SHEFFIELD SYSTEM OF CONTINUOUS DESKS AND SINGLE SEATS.

dual desks. The continuous desk has small fixed seats on separate pedestals, and with a low back rest. There are no foot rests. Even under the disadvantages seen in London, where whole rooms are to be found fitted with a single size, and where the seats are much too close together, many teachers advocate them. On the 10 sq. ft. basis, however, they lose most of their advantages.

In Breslau, where school hygiene almost originated in the ophthalmic work of Hermann Cohn, the majority of the schools have continuous desks with foot rests, and chairs four-legged with circular

backs. All the desks are the same height, but by the provision of three sizes of chairs, and three foot-rest heights, by slipping in additional thicknesses of wood, nine variations are possible (Oebbecke, *Zeit. f. S.*, 1911. 641).

In the English school, remembering the crowded floors that result from the 10 or 12 sq. ft. ratings enforced, the advantages of the dual desk may be summed—

1. They can be turned up to scrub the floors.
2. They are interchangeable in size from room to room.
3. The teacher can stand by the pupil in examining work.
4. The pupils can stand by their places for drill (although two cannot stand in the narrow gangways).
5. The hinged tops (in London) can be used as book rests.

Against these are the disadvantages—

1. The pupils are in close bodily contact.
2. Dust accumulates under the standards.
3. The pupil on the left has insufficient space to rest the arm in writing. Dufestel (*La Médecine Scolaire*, 1910. 246) puts it: "Dans une table à deux places il y a toujours un enfant de sacrifié."
4. Contorted attitudes are inculcated to prevent copying.
5. For proper use each desk should have two children of similar height, length of leg and arm.
6. Three pupils are often crowded on a dual.

To combat these troubles the Sheffield desking was used, its advantages and disadvantages, as judged from twenty-three London schools, not, however, originally planned for the system—

1. Floors are more easily swept, the simple standards not allowing dust.
2. The separate seats avoid contact and prevent overcrowding.
3. The teacher moves freely behind the children.
4. The pupils stand comfortably at back or side of seat for drill.
5. There are no movable parts to pinch fingers or cause noise.
6. The desks cannot be removed for scrubbing or re-organization.
7. A space between each row means more floor space taken up and the back rows farther from the teacher.

The teachers' objections to the Sheffield desking were that the seats were too small, there was often not enough room for boys about 12 years of age, and, further, although not generally expressed, that the bending over the children to supervise work was tiring.

To show the relative measures of the different varieties, dimensions corresponding to the middle size, or ten- to twelve-year-old children, with heights round about 145 cm., are brought together in Table 49.

As regards sizes, the seven sizes used in London vary by 1 in. from 16 in. (40·6 cm.) downwards, with desk heights varying by 2 in. from 29 in. (73·6 cm.) to size V at 21 in. (53·3 cm.), the sizes VI and VII being 20 and 19 in. (50·8 and 48·3 cm.).

The Committee of Experts in Vienna who spent several years working on the subject some thirty years ago (1892) arranged a

TABLE 49.

DIMENSIONS (IN CENTIMETRES) OF VARIOUS DESKS.

	Spellmann's, Hanover.	Rettig, Berlin.	London No. 2.	Bennett Dual.	Sheffield Continuous Desks.	Breslau Continuous Desks.	Vienna Dual.
Height of seat ..	40	39·8	37·5	38·7	37·5	37·5	40
Width of seat ..	25	28·7	—	—	—	28	29·5
Height of desk ..	66	64·4	67·5	68·7	62·5	62	67
Width of desk ..	—	38	—	—	—	37	—
Distance	− 3	− 2	+ 5	—	—	—	− 6
Distance of back ..	—	28·3	33	—	25	29	25
Length per place ..	55	60	50	—	50	65	56
Square feet area of room per pupil ..	48 10·75	11·8	10	10	10	15	—

TABLE 50.

VIENNA DUALS.

Standard.	Child's Stature.	Seat Height.	Seat Width.	Height of Thickest part of Back Rest from Seat.	Lowest Position of Desk Edge.	Desk.		Length of Desk per Pupil.
						Narrowest.	Widest.	
I	102–117	31	25	19	57·5	25·5	37·5	48
II	118–	32	25·5	21·5	60·5	23·5	39	50
III	126–	34	26·5	23	65	24·5	40·5	52
IV	135–	36	28·5	25	67	26·5	42·5	53
V	145–	40	29·5	25	71·5	28	45	56
VI	155–	42	31	27	76	26	45	60
VII	165–174	45	28·5	29	80	28	46	60

series as shown in Table 50, from actual measurements with various individual children and different models (*Z. f. S.*, 1894. 396).

An agitation arose among teachers for chairs instead of fixed seats, so that if necessary "five girls instead of four can sit at a desk."

The advantages of small tables and chairs, as worked out by the author in Bradford infant schools, giving elasticity, enabling class sizes to be varied, or rooms cleared, resulted in a wholly retrograde

move in the standards away from desks to tables. The move was really against the crowding of the dual desk, but ignorantly, instead of single desks, tables and chairs were suggested. For the ordinary conditions of life, or the dwelling-house, they are excellent. They

FIG. 51.—THE MINNEAPOLIS SEAT DESK.

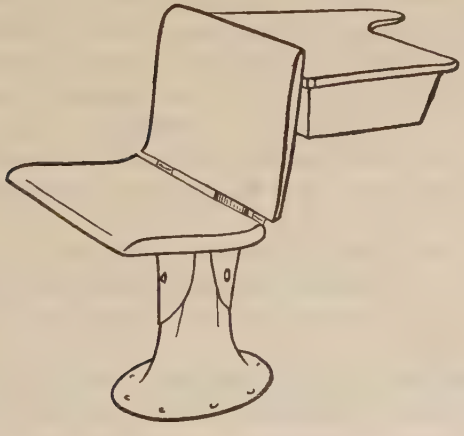


FIG. 52.—THE ELGIN ADJUSTABLE SEAT DESK.

were the provision of the old dame school, but on the 10 sq. ft. basis they are extremely unhygienic. The children are crowded round, without elbow-room, nearly half of them have their backs to the teacher, discipline suffers ; they also face each other in the best possible way for disseminating infections, colds, catarrhs, or

even the zymotics. The lighting arrangements are also unsatisfactory—in the faces of many or on their backs. The table and chair arrangement may therefore be left out of consideration.

Single Desks and Seats.—There now remains no other condition of advance educationally sound and hygienically satisfactory in both physical and psychical respects, than that each child shall have its own seat and desk. The seat and desk form a unit. This was always refused by the Board of Education, until the last issued regulations, in the simple statement that such were "unnecessary in elementary schools." The question of the single seat and desk is of greater importance as regards organization and hygiene than any details of orthopædics.

Single seats and desks should conform to the measurements already given. A plain locker desk, with a seat, having a sliding adjustable back rest, is the kind generally found in secondary schools. The heights of seats are usually 28½, 30, and 31½ in., and the difference 17½, 18, and 19, giving a desk edge height of 46, 48, and 50 in. respectively.

The next move came from America, where, in assembly rooms, arm-chairs such as are used for quick lunch restaurants were introduced and had a plate on the right side to rest a note-book. This was developed by fixing an adjustable table to the right arm, the left side being free; the pupils entered from the left side, and had a horizontal desk in front of them. A book cupboard, opening on the left side, was made under the seat. The Moulthorp movable school chair is a unit which became popular twelve to fifteen years ago. Then varieties of movable single seats, with tables made either in metal or wood, became common on account of their flexibility of adaptation to school purposes. The auditorium chair soon invaded the class-room. The right side was used as a supporting arm. The principle has also been applied to desks in series, the pedestal seat and desk, which are not movable and have to be screwed to the floor.

One of the best forms of single seat desk here illustrated is made in seven sizes, seat height varying by an inch from 11½ in. to 16½, then 18 in. The table heights varying from 19¾ lowest to 28½ in. lowest edge.

The English Board of Education "Building Regulations for Elementary Schools" deals with the subject of furniture of class-rooms—

59. It is advisable to keep the class-room floor level. If a platform is provided for the teacher, it should be about 6 in. high.

60. Seats with backs and desks or tables for all the children varying in size and placed at right angles to the window wall.

61. An allowance of at least 20 in. per older and 18 in. per younger at each table or desk required.

62. Desks single or dual, tables and chairs, sloped or level writing surfaces allowed.

64. In selecting seats attention should be paid to the following points—

(*a*) The height from the floor to the seat should be such as to allow the child when seated to rest its foot on the ground or on a suitable footboard. The upper part of the child's leg should be horizontal and the lower part vertical.

(*b*) The height from the seat to the writing surface should allow the child when writing to sit upright in an easy position.

(*c*) The edge of the writing surface should be almost directly over the edge of the seat. It is better that the writing surface should overlap the seat somewhat than that there should be any appreciable distance, measured horizontally, between the two edges.

CHAPTER XIV

THE OPEN-AIR SCHOOL

The open-air school, which, so far as climate will allow, seems destined to be the ideal of elementary education in future, has but a brief history. It arose out of treatment of phthisis adopted comparatively recently in pine woods of Central Europe.

In Vienna in 1903 half a dozen schools for the treatment of tuberculous children were instituted, and in 1904 the Vaterlandische Frauenverein in Berlin opened the school in the Grunewald near Charlottenburg. The intensive and intelligent handling of a hundred and twenty admitted soon spread its fame. At first the pupils were anæmic, debilitated, and probably tuberculous. The writer saw many with the diagnosis "Spitzenkatarrh," changes at the apex of the lung, but a little later the tuberculous were rejected. By the following year similar schools were in existence in Mühlhausen, München-Gladbach, and other centres. They were all situated in woods. At Charlottenburg the wood had light sandy soil covered for several inches with pine needles. At Mühlhausen, where ordinary book-work was only done in the forenoons, the children were in the deserted grounds of an old French château; whilst München-Gladbach had its school, quite a long way out of the town, in an uncultivated wood. Not only were the sites cheap and spacious, but the buildings were mere sheds or at the best the temporary Doecker buildings. The children were fed at portable trestle tables of the roughest kind. The whole curriculum was modified to active occupations rather than book-work. Life was being lived as an objective reality rather than in passive abstractions. The apparent success in each case was far beyond what is possible in the ordinary school.

In 1907, through the efforts of the Woolwich Co-operative Society who offered the use of a site, the Bostall Woods Open-air School was initiated under the London County Council. The lines of the Charlottenburg school were closely followed, and the most important point for the future of English schools was adoption of the midday rest, almost universal in Continental life.

The following year two similar schools were started in London, where, however, in the next fifteen years little further progress has been made, the want of sites and cost of land being alleged as

cause of delay. Playground classes were introduced, but they are a poor and inefficient substitute for the fifty open-air schools which are a crying necessity for London's debilitated children. Unfortunately, these now work out at about £40 (forty pounds) a place, but they are the type which are most required in the future.

Halifax started a school in 1908 at Bemerside House. Bradford had several, and Sheffield, Darlington, and other towns soon followed. Bradford took the further step of keeping children resident at the school from Mondays to Fridays; a course which has also been found useful in Australia.

Thanks to the Elizabeth McCormick Foundation in Chicago, the open-air movement got a fresh impetus in America in 1909. There it was demonstrated that the pine forest was not a necessity, but that even the city slums of Chicago could be adapted if the other requirements of unheated air, space, rest, and sufficient food, with unspoilt vitamins, were provided. Roof spaces could be utilized for playgrounds, and congested class-rooms could become open-air rooms. The first two model open-air rooms were on the roofs of buildings in the centre of Chicago, and the demonstration it has given of fresh-air work, of playgrounds, and opportunities for vitalizing the children, afford splendid examples.

The extension in America has been rapid, and whilst at first connected with the care of tuberculosis, the general prophylactic value of these efforts is now well recognized. By the end of 1921 there were over 3000 such classes in the United States (Milligan, *Illinois Med. Journ.*, 1922. ii. 469). The details of these schools depend much on climate and nationality. Holland and Anglo-Saxon countries have in the main followed the Waldschule and its sheds. France has inclined to the sanatorium type with substantial buildings; whilst in Italy and Spain a large variety of outdoor schools of varied kinds depending on locality now exist. South America makes much therapeutic use of sunbaths in the schools. The British Colonies have generally adopted improved British methods. Recently sunshine has had possibly an exaggerated value placed upon it. Alton, Chailey, and sundry scattered schools under Education Authorities have been run on these lines since 1924.

Purpose.—The purpose of the open-air school is to bring debilitated children nearer to normal health, train them in good fellowship, and create a desire for education. All means must be used to lessen the defect in the reserves of what may be called their nutritional capital, to stimulate metabolism by proper food, so that they utilize as well as take in freely. All wasteful output of energy must be avoided, whether it is in active over-exertion and fatigue, or in passive loss of heat. These schools growing out of this anti-tuberculosis campaign, now present many grades of effort. Under the present conditions of society every town and

every district has debilitated children—children handicapped by environment, suffering through the failure of the community to protect them. When medical inspection first began the pressing cases were those with tubercle of spine, hip, or knee. These cases are now much rarer. The original difficulty was to ensure prolonged stay in institutions. In 1906 the writer urged that " these children should be taken to institutions and kept till healthy, not merely relieved from the most urgent symptoms and sent out again to drag away months till urgent symptoms again supervene, as is the common history of such cases at present," and a residential open-air school of recovery was adumbrated. It first reached actuality in connection with the Cripple Schools at Chailey, organized by Mrs. Kimmins, with their sunshine and fresh-air life, and in the later more ambitious efforts of Sir William Treloar at Alton. Under public authorities day schools chiefly existed for the first few years. There is no possibility of drawing any hard and fast line in regard to tuberculosis, but in England two varieties of open-air school were suggested at the outset. One may be called the standard open-air school as it now exists, the other, a particular variety, was termed tuberculosis school, and intended to be both hygienically and educationally prophylactic for children in sub-normal health and from tuberculous environments. This whole prophylactic anti-tuberculous movement, the really only scientific way of directing social effort cheaply, by giving a distinctive bias towards hygienic living and education, was arrested for years from want of proper clinical appreciation of the disease, through the Board of Education insisting that a tuberculosis school must be for children not potentially or doubtfully affected, but only for those so advanced as to be presenting physical signs, and actually and undoubtedly suffering. The prophylactic schools, as distinguished from this narrower view of tuberculosis, have since been established in America and are sometimes described as preventoria. The purpose of the standard open-air school is perhaps best appreciated from the following note written in 1911 after four years' experience. At Birley House the children on admission " presented a miserable and uncared-for appearance, and as the weather was cold and windy, and many of them were suffering from common colds, it would be difficult to imagine a more wretched-looking class. They came from very poor districts, and most of them were badly clothed and dirty. They were poorly nourished, had carious and defective teeth, and were anæmic. At an examination of candidates nominated by teachers for admission to these schools almost every child seen is in a grave condition. A large proportion recommended are suffering from such lung conditions as fibroid changes, collapse, or bronchiectasis, all the result of repeated and neglected attacks of bronchial catarrh in the past.

Several had family histories or family environment of phthisis, and some had previously been under treatment for this disease. It is difficult to say which of the children are actively suffering from tuberculosis. Two only seemed to be suffering from phthisis, but this is the final stage of chronic infection. Phthisis nowadays in a school child means that it has never had a fair chance in life" (*Report of the L.C.C. M.O. Ed.*, 1911. 103).

These, then, were the pupils to be brought to a healthy and robust childhood if the school succeeded in doing its duty. They were really suitable for the type which we had suggested as tuberculosis schools, but a lack of common sense made them inadmissible unless in a comparatively advanced condition of indubitable tuberculosis, so, as shewn before, the ordinary standard open-air school had to take them. They were all quite unfit for any ordinary school.

These schools are officially recognized, and were paid special school grants, as for the physically defective; and the L.E. Authority can pay travelling expenses under section 69 of the Act of 1921, but must recover part at least from the parents under section 65. Some nine-tenths of the children in London use public conveyances to school coming from distances up to four miles.

Areas and Structures.—The simplicity of arrangements at Charlottenburg was striking, consisting of a couple of Doecker huts put end to end, and at another place a long shed, merely a roof over the ground, open on all sides. In the first London suggestions the English climate was feared, and the schools were only open for the milder six months of the year. The experience narrated in the London Report last quoted may be added to: "Opened in April, during the first few days the weather was exceptionally severe, the temperature running between 40° F. and 50° F. during the day and several degrees of frost being registered during the night. In spite of the inclement weather the school was carried on as usual, the children taking refuge in the Doecker shed during the blizzards of snow, and although most of the children came from homes with stuffy atmosphere, where closed windows are the rule, none of them suffered any harm from the unusual conditions of their schooling. Some ordinary colds in the head occurred, but there was no loss of attendance. During the late summer with a long drought, much sunshine, and a shade temperature daily exceeding 80° F. for weeks, the energy and vitality of the children fell off, exercise had to be curtailed, and there was a slackening in the weights of the children, partly due at Birley House to some attacks of enteritis. The autumn, on the other hand, was again wet and windy and unsettled, and on several occasions the old-time London fog reappeared. There were, however, no ill effects

on the children's health, and the attendance was steadily maintained."

The Bradford open-air school, established on a bleak hillside at Thackley, was kept open all the year round, following the Charlottenburg example, where the children played in the snow. It was soon recognized that for economy in working, and for establishment of results, continuous schools open the whole year round were best, due allowance being made for a summer holiday.

For the day school extensive buildings are not necessary. Generally some large house has been adapted, but fresh building should be avoided to carry out the open-air ideas well. Doecker huts and open sheds provide all the required cover for protection from rain or snow. In the record of one school only 11·5 per cent. of lessons were taken under cover.

The example of the open-air school soon modified ordinary school practice. The next elementary school built in Bradford after the beginning of the Open-air School was at Buttershaw, when practically all the class-room window area could be opened by a single lever. Glasgow built at Bernard Street large school-rooms spacious enough for single 26-in. desks for each child, and with verandas (*School Hygiene*, June 1917), and the Derbyshire open-window schools soon followed. A lightly built school opened at Shotts early in 1924 exemplifies the application of open ideals to the ordinary school.

The Bradford people established a residential open-air school. This is the only logical proceeding. In France where tuberculosis is prevalent—*L'Œuvre Grancher*—"*Soigner l'enfant suspect ou déjà malade aussi longtemps que possible, par une alimentation meilleure et la scolarité à la campagne*" was his statement of treatment in 1905. Removal of the children from tuberculous home environment was one of the great steps of sanitary advance, not yet sufficiently appreciated in English-speaking countries. The modification of the home environment is a matter of primary importance for large numbers of children. Much of the debility seen from failure of nutrition may be surmised to be due to the struggle against tubercle and other germ infections. School experience indubitably shews this to be in preponderating degree a domestic matter. Whether it be tubercle, favus, or scarlatina, familial infection is the rule, and compared with school influences the home environment is paramount. It may be possible for Care Committees to exert influence for good. They could seek out bad conditions and modify them by the dissemination of information, by getting windows opened, dark rooms light, and unhealthy spots clean. It is here that the school nurse—if Care Committee officials were eliminated and she were always permitted—could join with the health visitor and sanitary inspector in raising the health ideals

of mothers and the conditions of the homes, in spite of poverty and what it connotes, for poverty is the real enemy and main source of debility and tuberculosis. Healthy conditions in the home are as important for the future of these weakly children as is the provision of open-air classes, school feeding, or any other more obvious and direct attempts at amelioration. No great success is ever likely, except through the direct action of the school nurse, in following up each case. Whilst by these means one may do something for the debilitated, in the case of the child in the tuberculous home the day school is insufficient. Removal from the home to a residential school is the only satisfactory solution. *L'Œuvre Grancher* boards out such children in country places, or preferably at the seaside, so long as the home remains a centre of infection. The residential open-air school will then follow ordinary standard lines, with the additional provision for residence. The essentials are abundant air, sunshine, space, and good ventilation for dormitories, with regular and unremitting but unobtrusive observation and noting of the condition of the children.

Feeding.—The loss of heat in fresh air means extra calories required in the diet. Where debility and malnutrition are the result of poverty and hunger, an open-air school would rather aggravate the condition of retarded growth, although the children might gain in the qualities of resistance. Playground classes without feeding, referred to later, are a hardship, sometimes almost a cruelty, to poor and debilitated children. Many of these children may be suffering from vitamin poverty, to judge from the effects of milk or oranges. Many German mothers combated the blockade hunger by keeping their children all day in bed.

Some children were regularly followed up by the author for thirty-six weeks from the beginning of April. The relative growths were similar in all age groups, but are only given in Table 51 for girls aged $11\frac{1}{2}$, expressed as percentage increases on the measurements for the eighth week, by which time stabilization has occurred.

These results are set out for weights of boys and girls in the diagram (Fig. 53).

The New York fresh-air schools (*Buffalo Report*, ii. 85) were divided into two groups, one unfed, the other fed, but only to the extent of about 350 Calories, with milk and crackers; control children also being observed. The unfed children relatively lost weight all the time.

The C.O.S. people in New York think, according to Woodruff, that children taught in the open air without extra feeding improved more rapidly in many other respects than the same class of children in crowded class-rooms; but New York class-rooms have much greater space per scholar allowed than English ones. It seems evident that additional feeding must be given if full benefit is to

be obtained by this class of child in the open-air school. "Forestall disease by feeding," says the official *U.S. Bureau of Education Report in* 1914.

The school meal should have a relatively larger quantity of protein and fats. The insufficient nature for children of the

TABLE 51.

PERCENTAGES, LONDON GIRLS AGED 11¼ YEARS.

Increased Growth.	Weights.				Heights.			
	Open-air Classes.	Play-ground Classes.	Control Girls (E.S.).	Annual Rates, London	Open-air Classes.	Play-ground Classes.	Control Girls (E.S.).	Annual Rates, London.
Numbers	11.	69.	11.	—	11.	69.	11.	—
Measurements	26·7.	29·0.	29·5.	29·8.	132·2.	134·8.	135·4.	134·4.
Weeks from April—								
8	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00
12	0·75	0·49	0·62	0·80	—	0·29	0·22	0·26
16	1·87	0·91	1·42	1·60	—	0·59	0·60	0·52
20	2·24	1·77	2·73	2·40	—	0·96	0·90	0·78
24	3·36	2·81	4·22	3·20	—	1·33	1·30	1·04
28	4·60	4·62	6·00	3·80	1·70	1·56	1·70	1·30
32	6·74	—	—	4·60	—	—	—	1·56
36	7·11	—	—	5·30	2·50	—	—	1·82

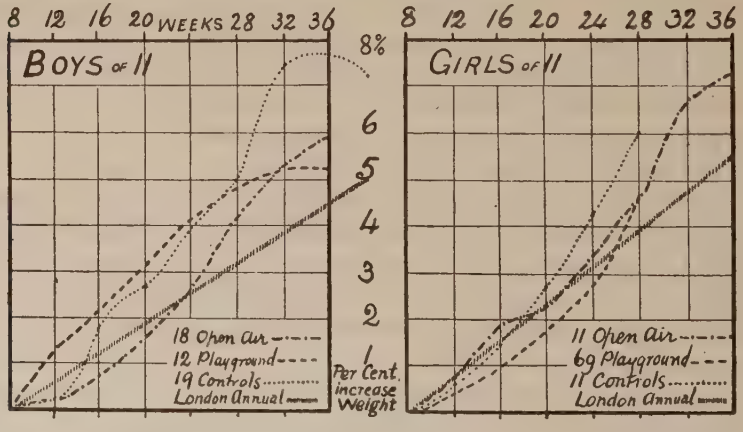


FIG. 53.—GROWTH OF CHILDREN IN LONDON OPEN-AIR SCHOOLS.

protein of peas and beans, and the great value of milk protein has to be stated, as many of these children are suffering from cheap diets. High-grade proteins and meals in which the vitamins have not been destroyed by keeping or cooking are wanted. Even apparently healthy town children grow more quickly if fresh vegetables and green-meat are added to the diet. Open-air sunshine on the skin adds to the value of the diet, but sunshine through

window glass is inert in this respect. Potatoes and milk form a good staple in the open-air or any other school. Town children may refuse vegetables in stews and hashes, picking them out unless grated down previously. They often desire heavy, stodgy materials.

In the London schools three meals are given daily: breakfast at 9 o'clock of porridge, *ad libitum*, sugar and a half-pint of milk. Dinner at 1 p.m., 4 ounces of meat or 5½ ounces of fish, 6 ounces of potatoes and a quantity of vegetables, followed by pudding, 6 ounces. One day a week a large plateful of lentil or pea soup with bread was given instead of meat. Tea at 5 p.m. was a half-pint of milk, weak tea, or cocoa, with bread and butter, or dripping and bread, and jam or cake. A few children were also given milk in the middle

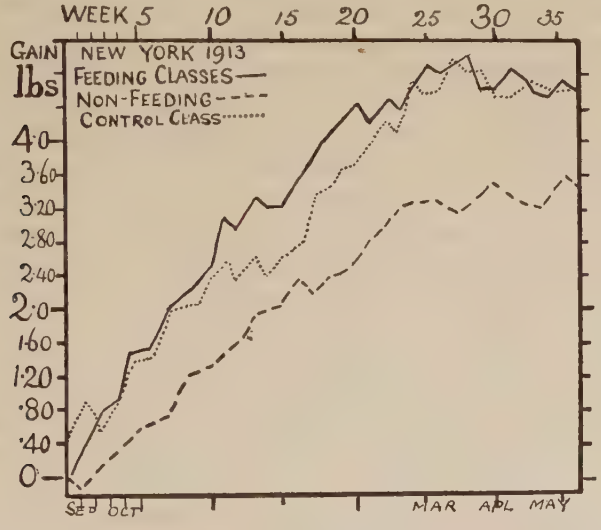


FIG. 54.—GROWTH IN NEW YORK CHILDREN.

of the morning. Much care is necessary on the part of the school nurse to avoid monotony in the feeding. Green salads should have regular appearances. The meals must not be given in a niggardly spirit. So long as children clean their plates they are not wasting food. There should always be three meals a day. Probably less than the three meals would lead to loss of grant. The character and educational value of this work is discussed in the chapter on diet. Fresh milk and cod-liver oil as separate "meals" will be necessary for a considerable number of children. Miss McMillan has insisted that the more the children improve the hungrier they seem to become. "Double rations of air, double rations of food, and half-rations of work," as an American writer puts it, is a thoroughly sound ideal here. The New York Society for Improving the Condition of the Poor had investigations conducted which

resulted in the conclusion that every growing child requires a quart of milk a day if its growth is to be properly promoted.

Rest.—One invaluable item was almost unwittingly started in the adoption of the daily resting time, copied from Charlottenburg. A resting period intercalated in the twelve-hour day is a desideratum for all growing individuals. The siesta, indeed, is the rule through Central Europe, Italy, France, Germany and their neighbouring lands. Every growing child needs a period of rest, other than the nightly sleep. The younger the child the more protracted the rest rhythm. A good sleep is absolutely essential for all infant departments, and without it attempts at education are wasted in great measure after the middle of the day. Some sleep like logs and their night sleep is none the worse. In adopting the Charlottenburg rest, then, more was done than was thought at the time. The rest thus introduced into elementary education comes suitably after the main meal in the middle of the day. Children rest and sleep better when lying down. The hammock-chair or steamer deck-chair type is quite unsatisfactory. A camp bed or a portable canvas strung on stretcher poles supported by a collapsible trestle at head and foot is the best. This rest-time should be not less than an hour, and may with advantage be longer for those below nine years of age. One and a half hours is useful in the open-air schools. No reading or playing should be allowed in the resting hours.

Clothing.—When sitting, and during the midday rest, clothes should be provided, especially for the legs and feet in cold weather. The amount of clothing may easily be overdone. It should always be under the control of the nurse, as so many teachers cannot be trusted to use common sense in matters of health observance. Their training generally omits this aspect of education, or at least gives it quite insufficient emphasis, and in England it is not looked on as school-work by many teachers. One American writer notes an open-air room where although outdoors it was below freezing, in the room it was 67° F. and the children sitting sweating in heavy woollens and top-boots.

There should be bathing arrangements; the shower bath, having a particularly stimulating effect on children, is adjuvant to metabolism. Two baths a week for each child is advisable. When severe weather is to be expected as part of the climatic condition, heating should be available for the dining-rooms, and bath- and dressing-rooms. It would be well if the class-room could be heated, but there should be no hot air, no warmed rooms with windows closed to conserve heat. Radiant heat from floors, and wall radiators or pipes, but open windows and cool air. In extremes of cold found on the American Continent, children are provided with thick blanket bags. So long as the hands are right the child may be taken to

be comfortable. The Chicago scholars in the Elizabeth McCormick Schools have Eskimo suits, which are made in five stock sizes, consisting of a heavy jacket with hood, big knickers, and lumbermen's boots. They are slipped on over the rest of the child's clothes.

It seems doubtful if sitting still under these conditions is to be recommended. The improved lymphatic circulation from constant movements in the ordinary business of class-work out of desks shews a benefit. The Swiss children at Dr. Rollier's establishment play about naked in the snow and sunshine. Many young London children of the middle classes appear unclothed from the middle of the thigh, in the cold and wind of November. How much they suffer it is impossible to say, but they are well fed and actively exercised children as a rule, not the debilitated type admitted to open-air schools, and no doubt even they are to some extent hindered in growth by the habit. Cold feet have to be provided against, and large felt slippers are useful for any who are kept sitting. In very cold weather desk work should be omitted for work with plenty of movement and change of position. Exercise is the best remedy for cold feet, but if too much energy has to be used in keeping warm many of the advantages of the school will be discounted. During the rest period warm clothing will also be required, and in cold weather protection from the wind. Despite the immense value of unscreened ultra-violet radiations in vitalizing effects, protection from violent sunshine or rain may sometimes be necessary. For either hot or cold this is best obtained by a simple roof, supported on pillars and screened if necessary on one side as shewn in the Melbourne class-rooms. With collapsible desks it is possible for all to be under cover in two minutes. Some of the Doecker portable pavilions made to open completely on one side are useful, or may be arranged at the side of a more permanent building. When chairs are used they should have solid backs as protection against the wind and cold. The class must be oriented with respect to sunshine and the eyes, the line of sight of the children being not less than 30 degrees with the direction of the sun. Glare is always to be avoided in school work.

The open-air rooms advocated in America are obviously wanted there owing to the high temperatures of the rooms. They are substitutes available in towns, and may be noisy and dusty. The windows may be too low. French windows tend to cause cold feet. The window-sill should not be higher than three feet or it casts a shadow. The floors require particular attention lest they be cold. They should be of somewhat non-conducting wood or composition, or be heated from below, as tiles or cement are likely to be very cold.

Milligan, who writes of the New York open-air rooms, says graphically that the principles can "be applied to any room,

dungeon, den, or other place of confinement." These open-window rooms with no feeding and no heating, although stimulating and hardening for normal children, and to be recommended for Eton or Harrow, have the objections already mentioned for the debilitated.

A report from Chicago after a year's experience declared that warm, dry air made children dull. "Nasal catarrh is common in school, about one-third have it in cold weather. In the open-air rooms of the Graham school we cured all the cases of catarrh in 90 pupils in eight weeks, while 90 pupils in the regular dry, warm rooms, shewed 40 cases of serious nasal discharge" (*Amer. Phys. Ed. Rev.*, 1910. 600).

The general principle of an open-window or fresh-air room is to be thoroughly recommended, and should be the type on which future class-rooms in temperate climates are provided.

The Selection of Children.—As the school will be open about twice the number of hours, and works out at least twice the cost of the ordinary school, and where proper food and coverings are provided may be a great deal more, careful selection of pupils must be made.

The cost is amply repaid to the community in the increased efficiency of later years. The waste in money spent on those dying from tubercle ere useful work has been done is enormous. There is a tuberculosis tax on every industrial community which must be paid in money or in lives. Unfortunately, it still is mainly paid in wasted lives. This will remain until public service is measured more by benefits conferred than by rates saved.

The first selection of children may be by the teacher, or children are noted by the doctors in the statutory inspections, or notified from hospitals. Where doctors make the first selection, a better intellectual type prevails than in those first selected by teachers. These children often come from families on the verge of destitution. A record of each child should be prepared shewing the family circumstances and social conditions, as these may influence the school effects.

The Sheffield Report for 1912 contains (p. 41) an analysis of the incomes of 109 families of open-air scholars. After deducting rent, 80 of these families had an income of less than five shillings per head, and 14 had five to six shillings, only 15 being over six shillings per head.

The open-air child in America comes from a family of 6·2 persons. Chicago families with adequate income average 5·2; with inadequate means, 6·4 persons. The American nurses before Prohibition days, reported the cost of drink as the most serious outlay in the families from which open-air scholars came. As it is the home environment that has to be modified, its nature should be known,

especially in regard to exposure to tubercle or a heredity of rheumatism.

Examining children for these classes in the early days, the writer himself found many of the most needy barred out, in what for some appeared almost a matter of life and death, by strict insistence on regulations insisting on a payment of half a crown a week for each case. Dr. Clive Riviere found 51 per cent. of the cases he selected excluded on this ground (*L.C.C. M.O. Ed.*, 1909. 87). As late as 1923 Reports of the King's Canadian School at Bushy Park emphasize the deterrent effects of charges on the poorest classes. As regards Bushy Park, this, fortunately, has been altered, so that no child is excluded now. In London bad arrears in payments are mainly from families with unemployment or in receipt of parish relief (1923).

The children selected from the educational side (teachers, etc.) are then examined specifically for open-air schools by the school doctors. A complete examination should be made, definitely noting at the time such particulars as date, age, height and weight. A general assessment of nutrition should be recorded in a form that can be checked later. Valuable, too, are size of heart, hæmoglobin content, presence or absence of eruptions, pustules, nasal or aural discharges. If possible some record of the child's hours and conditions of sleeping should be added. Phthisis, tuberculosis, children with discharging sinuses, asthma, rheumatism, and chorea, some heart patients, and cases of albuminuria should not be taken in the ordinary open-air school. The invalid school or sanatorium is more suitable.

Attempts to classify cases in later months are frequently made almost impossible by the indefiniteness of previous card entries, even in such matters as the date of the first notes, or by impossible birth dates.

The height and weights of the children should be charted by the nurse every two weeks. They fluctuate in the first three or four weeks, depending as they do on the child's previous condition. To judge comparative effects, the writer has usually taken the height and weight at the end of the fourth week as the datum for the later effects on the child's growth. Temperature and season affect them, so that for strict scientific work controls taken from children of approximately the same age and size at the same period and season are necessary. The seasonal variation has been referred to in the chapter on growth, as neglect of this has been the cause of many mistaken deductions. An instance may be quoted in the unjustifiably pessimistic report on after-results in the Sheffield Report of 1913; reproduced to the London Authority in the following year, possibly in ignorance of the fact that the whole subject had been worked out by the writer when School Medical

Officer in London open-air schools half a dozen years previously, and published in their own official reports.

Probably hæmoglobin content also varies with season. Increase of hæmoglobin, however, except in very anæmic cases, may not necessarily mean health. The average steadily increased from year to year with increasing starvation of the Leipzig children in 1914–18.

Blood pressure observations have not been used as they might have been. It is low in tubercle cases, but increases in the open

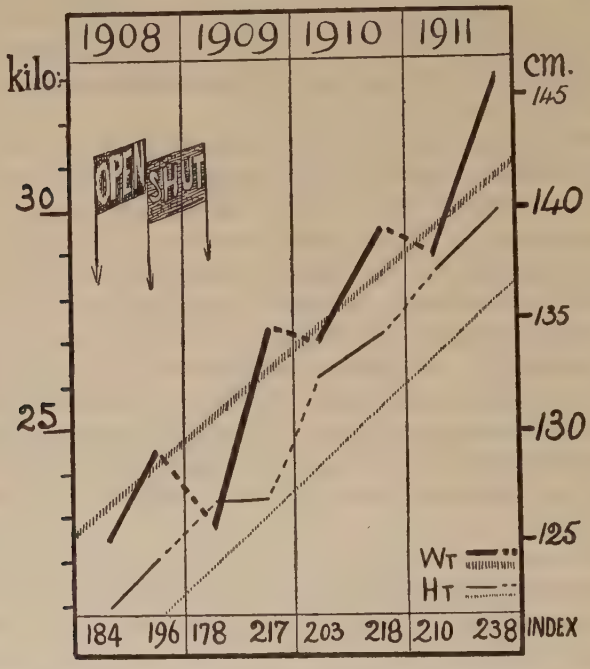


FIG. 55.—GROWTH OF TWO BOYS DURING SUMMER IN OPEN-AIR SCHOOLS.

Attending open-air school in summer and ordinary school during the rest of the year. London annual averages shaded lines.

air, and may rise to normal to remain there as long as in the open air. In the more advanced cases it is low indoors, higher out of doors, and as improvement sets in remains up even indoors (Hoobler, *Am. J. Dis. Child.*, 1912. iv. 307). Fresh air in stimulating also raises the blood pressure in most children.

The improved metabolism, removal of waste products and better circulation through the brain shews in the sense of well-being, the smiling, happy faces of the children.

The feeling of being part of a social community, and the interest the children get in their various doings and the part they play in common aims and actions, makes the time seem all too short. This

increased metabolism in open air L. Hill shewed for crippled children in splints to be 40 per cent. more than the children in the Calori meter Chamber, and children in open-air schools had a 20 per cent. increase three months after admission.

Contagious diseases do not seem to run through these classes. Probably the increased space and greater separation has to do with this, the velocity of infection (p. 664) being diminished, whilst immunity resistance is increased to deal with any dose of infection over the time it is administered. Colds are rare, coughs disappear, ecthymatous conditions fade away, and discharges of eyes, nose or ears tend to dry up. Few records exist of outbreaks. One limited series of diphtheria cases occurred at Sheffield in 1913. Chronic absentees at previous schools became regular attendants at the open-air school.

The teachers require to raise themselves from the usual scholastic rut, to get the fresh-air ideals well into their minds, lest they merely conduct a slightly modified indoor school routine in the open air. There will be many difficulties in trying ordinary school-work.

Dust and wind materially affect written work. Upton notes that writing in gloves improves penmanship, probably by eliminating the fine finger for large arm movements; it also diminishes fatigue. Free-arm work is best for the outdoor school, and what writing is necessary can be done on paper blocks.

The writer once visited a beautiful site in a dry, sandy pine-wood, by the side of a lake whose other shore was not visible. All the advantages of sun and air and shore were largely discounted by the presence of an ordinary school time-table, of ordinary desks, and of teachers who were only conscious of the restlessness of the children, the constant distraction of their attention, and the difficulty of getting good results in the copy-books.

The estimate that two hours' daily schooling for five days a week will keep children up to standard, is given in the U.S. Bulletin in 1916 (Kingsley and Dresslar), and in the fee-paying school attached to that at Charlottenburg, twenty-five-minute lessons did as much as forty-minute lessons in the ordinary schools (Neufert, *Zeit. f. S.*, 1911. 429). The teachers will make or mar the school. The routine teacher, without originality or spontaneity, must be got rid of from the open-air class as soon as possible. A special type of teacher with flexibility and adaptability is wanted. The motor type of brain is of advantage in the open-air school—the person who does, instead of talking. The school, too, often brings out personality in a surprising way in the teacher as well as in the pupils. The experience of Shrewsbury House (1924) is that the average open-air school child is very backward, being three or four years behind calendar age in school attainments, yet the rate of progress is such that they reach Standard VII at

an age only slightly higher than normal. The average length of stay is three years. It has been said that teachers convalescent from phthisis might resume work in these schools ; but they should not be in school at all. Cases of arrested tubercle, cases with tremors or neurasthenic breakdown, Graves's disease, or nervous strain are not wanted here as teachers, nor are those with throat, heart, or kidney trouble.

The open-air school is not a place for a teacher who cannot do a full day's work without undue fatigue. Although the tension of maintaining discipline is much reduced, continuous, almost individual, teaching is wanted, and classes should never exceed twenty. Headaches, backaches, feelings of exhaustion towards the end of the day, become very uncommon. The vitalizing effect is thus also seen in the teacher's health.

Like other schools, the open-air school needs holidays. Both children and teachers require some weeks' complete change of routine, physically and mentally. The freedom from school discipline for a time, the whole day to do what it likes, is an incalculable advantage in a child's orientation towards life—to allow it to find itself. It is here that secondary schools for girls so often fail to accomplish adjustment. It should be the rule for three or four months for every child about puberty.

Apart from this, the school itself often needs repairs, cleansing, ornamentation or alteration best done at holiday seasons. It is thought that the children may suffer, but the usual holiday time in Summer is the period of slack growth, and with illness at a minimum, before the Autumn spent in heavy growth. The risks of deterioration are then at their lowest. For the very few with no available home the care organization should be able to find country homes or holiday camps.

The nurse has to watch how the children comport themselves, how they eat and sleep, whether they are good tempered or irritable, and also to call the doctor's attention at once to any great change in the records she makes. The children admitted have had a record made of their condition on admission. They must now be more carefully observed to track out the causes of the debility.

It would be useful if the doctor recorded clearly at a date noted and within the first month of the child's attendance, his exact diagnosis as to probable causes. The causes of debility in regard to malnutrition have to be excluded, and all possible causes of chronic focal sepsis eliminated. Most particularly have the teeth to be recorded as to their functional capacity, sometimes very defective, and again as to obvious septic foci. Out of 240 children admitted to London open-air schools, dental examination shewed 215 in need of treatment ; of these, 41 merely required

stoppings, but the remaining 174 presented every degree of foulness, sepsis, and decay (C. E. Wallis). School dentistry has already done something to diminish this.

Within a week or two the rates of growth should be increasing. Here again watch has to be kept. Children who fail to grow must have a cause behind it. Sometimes a dilated heart suggests obscure toxic causes, sometimes they are not eating properly, leaving fats and avoiding vegetables. Sometimes tonsils and adenoids are septic. The growth of these children is affected by further illness, or the necessity for fresh adjustments. Measles arrests weight at once, and the dip in the curve lasts some weeks. An attack of diarrhœa in Summer will have prolonged results. The removal of a tooth or tonsillectomy occasionally acts like shock, and takes weeks to get over, so far as growth in weight is concerned. On the other hand, the constant adjustments for a common cause, the co-operation in the same work, the give and take of the outside life, has a subconscious psychical effect which enhances and is enhanced by the improved metabolism. The taming effect of a daily glass of milk on a fretful, peevish, or passionate child has long been known in the poorer schools. In the open-air school the effect is more marked. *The Open-Air Smile* is the name the Chicago workers gave to their little journal, and it recognizes the beneficent socializing effects that follow a healthy sense of well-being in the whole herd. The open-air school is a most efficient engine for turning out good citizens.

Quoting from the Coventry Report for 1919 : " These good results have been attained by a plenteous diet of simple, good, and varied food, regular hours, much rest and sleep, and the cult of the bath—factors that are probably of as much importance as the fresh air nature of the life."

The work of the open-air school, then, embraces a multitude of factors of health which can be grouped under a few heads.

(i) *Air.*—Fresh air and light which by heat removal and good ventilation stimulate metabolism.

(ii) *Food.*—The provision of suitable and sufficient food.

(iii) *Exercise.*—The improved respiration, blood circulation and lymph removal from the tissues, by the constant movements and changes of position of the children. The stimulation of clean skin and the shower bath.

(iv) *Improved education.*—The diminution of unnecessary educational memory tasks and literary work. The substitution of the actualities of life for mere sets of ideas, things instead of symbols, the concrete instead of the abstract, and the continued suggestion and autosuggestion of healthy living. The rosy cheeks, laughing faces, and active movements are an education in themselves.

(v) *Rest.*—In daily rest there is not only diminution of fatigue

and time for recuperation physically, but also time for assimilating and digesting ideas received.

All these are necessary if full benefit is to be obtained. Any educational routine is defective in so far as any of them are wanting. They are also factors which should apply to every child in elementary education.

Tuberculosis schools will be further referred to under that disease, and the suggested cardiac or rheumatic convalescent schools in connection with heart cases which in many places are either treated in invalid schools or in open-window rooms.

In England a separate grant for medical treatment of tuberculosis is paid, and also the "special schools" grant for education.

Open-window rooms, and fresh-air rooms, fall short when there is no feeding or where the ordinary desk routine gives the child no relief. Sir George Newman's idea (1918) that "the sole requirement is that one side of the room shall be open to the outside air" ignores these other essential factors. There may, indeed, be overcrowding and stuffiness in a playground class. Whilst the 10 or even 12 sq. ft. basis prevails in spite of the potential gain from open windows, these rooms may be, and often are, quite unhealthy, whilst the omission of all the other factors of betterment is not compensated for by the absence of a wall.

The writer fully agrees with Terman when he says, "a perfectly ventilated school-room is of little avail to children who are held to sedentary book-work for six or seven hours a day." All the postulates of the previous paragraphs must be fulfilled if a class is to be recognized as one in which full health should be attained.

Detroit, which at the present time (1926) beams forth a bright light as one of the cities where the health of future citizens is logically treated, and placed before other considerations, has open-window rooms. The daily routine is somewhat similar to that of the open-air schools, except not so intensive. They emphasize regularity of rest, play, and good feeding. The pupils are weighed every two weeks, and are discharged into the ordinary class-rooms when they definitely improve. If they do not improve they are recommended for the open-air school.

Open-air classes in parks are also defective, if feeding and rest periods are omitted. Playground classes were suggested as inexpensive substitutes for open-air schools where some benefit is to be expected, and as they have been largely used in London, some account of this experience is worth giving. They rank administratively as ordinary school classes. Parks require full use by school classes at the time when most unused by adults.

In the first year of experimental working four varieties were tried.

Type A.—Delicate children of equal educational status, chosen from neighbouring schools by the school doctors. The same class works in the open air all the summer. This type is most useful, but by a financial juggle is supposed to be ten times as costly as the others, owing to a special teacher having to be appointed. The children would, of course, have to be taught in any case.

Type B.—Delicate children of varying educational standing chosen from the same school. The same children are in the class throughout the period. This type presents obvious educational difficulties, but is supposed to be much cheaper than type A. Probably the actual cost is about the same. This type might be abandoned.

Type C.—Standard VI is taken out in the playground for the whole summer. This is the most popular type. There is no health selection here. This should be applied in nearly every school.

Type D.—The various standards are taken without respect to health in the playground in rotation. Each class will have half a day every ten or twelve days. It is a popular variety of some, but scanty hygienic benefit. Where there are not the other types this should be the universal rule and more playground hours arranged. It would then approximate to the American platoon system.

The benefit from Type D as worked at present is so trivial that this type may be omitted from further discussion. In these classes as conducted in London, growth as measured by stature and weight is retarded or hindered. At the same time, nutrition is improved as judged by the hæmoglobin content of the blood which increases about 8 per cent. This may be purely a seasonal variation or partly the want of extra feeding, to judge from Leipzig children. Research on this point has not been followed up in London. The protective mechanisms of the body appear improved; there is, as already noted, less catarrhal disease, discharging ears tend to heal, ecthymatous sores to disappear. The children are livelier, happier, and most contented. "You are not so sleepy," as one little girl put it. There is more movement, more life, and the possibility of frequent short "nutritive" three-minute exercises. Rugs and waterproof capes were available in many cases. Awnings or wind screens are necessary to protect from sun, wind, and rain. In one class examined the doctor found 14 out of 29 had feet at the time actually wet. Old desks often under covered sheds have generally been used with tarpaulin to cover them when necessary. No desks should be wanted in playgrounds. Black-boards have to be fixed to walls, as if on stands they may blow over, or be easily upset, with considerable risk of accident. They are necessary.

The failure of the teaching side to appreciate the playground work is seen in Inspectors' reports. They report work in which the children move about as undoubtedly successful, but work in which they are required to sit still appears to undergo "considerable deterioration." The work is untidy. It is a struggle against adverse conditions. Some schools, not necessarily poor ones as

regard class-room work, but with somewhat rigid and unadaptable methods of teaching quickly succumb under the new conditions.

The obvious lesson seems that desk-work should be taken for a couple of forty-minute periods indoors. The main idea in more successful classes was to utilize freedom impossible in a class-room, to get activity of both body and mind. Probably for all schools there could be devised a summer curriculum differing in its increased activities from the more literary and sedentary winter curriculum. The playground class, too, will help in the interregnum whilst 10 ft. becomes 15 ft. floor-space requirement.

When these classes are surveyed, it is evident that economy is the main reason for their existence. They avoid other provisions, they are cheaper than open-air schools, but they fail on this very ground. They do nothing like the work they are supposed to do as substitutes for open-air schools.

The value of open air alone has been over-estimated. Children do not live on air, and the other factors of equal importance in the open-air school are here largely evaded, or neglected, to save the cost.

Necessity for Increased Feeding.—The open-air schools and playground classes are intended to make their pupils more fit physically and educationally than they would be in the ordinary schools. Their original object was to improve debilitated children who were just maintaining growth in a poor and miserable way. Fresh demands are put upon them by all forms of outdoor work, whilst some other school demands are lightened. There is more movement, more expenditure of muscular energy, both good in stimulating nutrition ; there is greater demand for heat, to counterbalance increased loss in the open air. Only one way exists of meeting these demands, and that is an increase in the food supply. Good feeding is, therefore, a necessary accompaniment for all open-air work, and without it the open air is a burden rather than a help to the debilitated child without reserves, or even those who are healthy and are using all available energy in rapid growth. " Eats like a navvy," is proverbial. It is in this requirement that the open-air school succeeds whilst the very few Playground Classes of Types A and B markedly fail. The A and B children lose weight compared with controls of the same age, social conditions, and over the same period. The doctors' reports are unanimous on the necessity of feeding for these children, but it is often doubtful whether these reports ever reach the minds of those in responsible authority. A typical report from Battersea : " One is disappointed in not finding more improvement in the physical and mental conditions of the children after six months in an open-air class. The following allowances have to be made : want of proper and sufficient clothing and feeding, and poor home conditions," and in many cases milk

recommended by the doctor is not given, cut off by Care Committee ideals of social service.

More Need for Rest.—Again, the growing child, and especially the debilitated child, requires considerable opportunities for rest and recovery from fatigue. Even in the best schools about a quarter of the children shew functional changes from chronic fatigue of postural muscles. The open-air school alone supplies the want of the one or two hours' daily rest, with sleep, needed by every growing child. The elementary school fails most lamentably in this respect, deforming the children by chronic fatigue for want of rest (scoliosis, etc.).

Other conditions already referred to in connection with open-air schools are the elimination of much educational strain by removal of purely scholastic excess in studies, which brings in real work actions and objects, with resulting brightness and alertness so characteristic of the open-air child. Daily milk works wonders, but feeding is necessary for all outdoor children, not for one here and there, and as it is required by the conditions of their schooling should not be spoilt by charges. It is an educational requirement which should not come under the Act of 1907 requiring payments.

Another variety which must be included as open-air educational work is the school journey. This is taken by some to mean a day or half-day spent out of school in some park or rural district. It should be called an educational visit when limited to a day. It has enormous educational advantages. The break in the routine of the class-room, and everything concerned with this expedition is remembered and talked over, and visits to places of educational interest, whether historical or natural, if not too often repeated, may in this way have ten to twenty times the educational effect of the same time spent in school. "We hear, read, and talk too much, and see and do too little," is credited to Richard Wagner, and might well be taken as a slogan by present-day educational reformers. The educational effects are much greater than the hygienic, although these are existent also (*Typical School Journeys*, 1909, Isaac Pitman & Sons, 1s. 6d.).

This variety of school-work was opened up in 1908 by the recognition of the school journey, including residence beyond the county as counting for school attendance under the Act.

Whilst these short breaks have the advantage of novelty, and impressiveness educationally, their hygienic importance in other respects is comparatively small. The school journey from the doctor's point of view is more than a rare day trip.

In Central Europe, Germany, Austria, and Switzerland they have been long established, and a distinction is drawn between a "Schulwanderung" (school journey) and "Schülerwanderungen"

(scholars journeying). In the one the school as a body marches, in the other bodies of pupils under direction make expeditions. The second form, which is the form usually followed in England, is the most educational.

Various societies and associations (" Der Wandervogel ") support these expeditions, but they are in many cases also associated with non-alcoholic propaganda, vegetarianism and other cranks, and have been written against, the opposition being mainly on moral grounds (Bluher, *Der Wandervogel*, 3 vols.). The third volume of this book, on the history of school journeying, treats it as a social phenomenon from the Freudian standpoint. One Berlin Society spent 200,000 marks (then £10,000) in promoting the movement in 1913, although most journeys are self-supporting. As the climate is not unlike our own, much experience can be gleaned from the numerous German works on the subject.

Children soon tire of the life ; two to four days is enough. For older children (15 to 18) up to a fortnight is usual. The minimum of baggage is wanted, the most useful being a loose woollen cape to reach to the knees. Twenty-five kilometres (16 miles) is sufficient task, and 50 kilometres for those untrained is perilous to the heart (F. A. Schmidt-Bonn). Those wandering in hilly districts do better than on the flat, and healthy children wandering gain weight faster than controls staying at home.

Since the War the Prussian Regulations require one day's outing each month for the elementary school children, and children of all ranks must now attend the public schools, as no other elementary schools are permitted. A truly democratic ideal still remote in England. In our own country there has been a form of this exercise stretching back before the era of school doctors, in the hop-pickers. The children who go " hopping " are usually ten years old at least, and often are of better social condition than would be expected. Generally one of the parents accompanies them ; the average stay is sixteen days ; they live very roughly and frequently return verminous, but gain distinctly in health. Some return with septic conditions, chiefly dirt infections of eyelids and conjunctivæ, but as a rule discharges and sores tend to heal. In addition to the hop-picking, there are many agencies through which children go to country homes or attain holidays. So much did this item of holiday migration affect statistics that the writer made a careful estimate of its effect. During the summer of 1906 the Children's Country Holiday Fund sent 38,000 away. During the vacation, out of 107,584 children over 5 years of age in 320 departments, 35,406 had spent more than a week out of London, the total weeks being 75,787. This amounted to 17·6 per cent. reduction of the school population throughout the holidays. As there are 750,000 elementary school children and 150,000 who do not attend elementary

schools, and of whom the majority will be out of London, the diminution of child population is at least 20 per cent.

Many school camps have been useful holiday arrangements. For instance, in Surrey the Henley Fort on the Hog's Back gives fortnight outings, counting as school attendance, during the summer.

The education is incidental rather than formal, a wise arrangement. It was closed for a week in 1922 because funds failed the inmates, not very creditable to the authority of a rich county.

The King's gift to the L.C.C. of the use of the site and buildings of the Canadian Camp in Bushy Park as an open-air school for boys has possibly started a new movement. Three hundred boys a month come here for a month each, to live the open-air life, be well fed, and yet learn to regulate and comport themselves for the common good. The beautiful grounds, with trees and streams and wild life, gives them an association with nature. Even the teeth are attended to, every boy returning with a clean mouth. The psychological effects are so obvious that it is almost evident that for all children the break between the primary school and secondary education should be marked by two or three months for mental adjustments at this particular period, free from the ordinary school pressure, and constrained only by their sense of what is owing to themselves and their fellows. A similar institution, but on much smaller scale, cares for girls at Margate.

The Homerton School for the Deaf instituted for many years a holiday camp at Osea Island, with great benefit to the pupils.

The regular school journey, to which some contribution in cost is often, but not always, made by a grant of the Authority, the rest being collected by children and teachers, lasts from a couple of days to as many weeks. The benefit of two weeks is a great deal more than twice that of one week. The programme has to be made out some time beforehand, and to be approved by the Board of Education. In such details Whitehall is a costly nuisance, often supervising technical matters by people seemingly quite incapable of a sound judgment concerning them. Decentralization of all this detail is wanted to cheapen education.

It will be valuable experience to the doctor if he can manage either to accompany through, or occasionally to meet the journeyers *en route*.

Each child should be medically examined about a fortnight before the start, to ensure getting treatment if necessary. A final review by the nurse as regards nits, scabies, and so forth is useful. The child's physique is the important thing, especially heart tone, back, and feet. Young children should not come ; they should be 10 to 11 years old at least.

Each child needs an extra suit or dress, extra stockings and underclothing, also brush, comb, towel, and overcoat. The dark-

blue school jersey, warm and roomy, should be compulsory for boys, and no collars allowed.

There are two kinds of journeying.

A. The journey chiefly as a means of improving the physical needs of the child. Here abundant skin stimulation from the fresh air is needed, with no more fatigue than can be avoided, and plenty of feeding and rests.

(*a*) A seaside excursion has many tonic effects, does not overtax the children, and whilst very interesting is also indirectly of high educational value.

(*b*) Residence at a centre, preferably with hilly country about it, and daily short excursions, easy at first and more strenuous later. No child should get exhausted. Appetite should be increased, and the cardiac tone improve daily. This is suitable for children of better physique than those sent for the seaside holiday.

B. Holidays mainly from educational value and long excursions for parties of carefully selected children. Flabby, ill-nourished, or debilitated children must be excluded.

It is advisable that all should be of somewhat similar physiological ages. Sight-seeing is more exhausting than simple travelling. Short spells of work and short rests do well. Frequent small drinks are useful. Lunches can be carried. Adequate feeding is necessary, the main meal being after the day's work is done.

Ten hours' sleep should be secured. Rests also in every twelve hours must be considerable. The average length of an excursion being about six miles at two to two and a half miles hourly.

From observations on the dilatation of the heart, Riviere concluded that the danger of the holiday excursion lay in the persistent, wearing grind of the excursion. He takes the view which the writer has, that for all juveniles the natural instinct of play exercises them by short, very violent efforts, interspersed in moderate activity and frequent rests. Riviere, therefore, suggests that the playing-field, among companions of his own age, is the proper physiological recreation and exercise, and that the school journey should be modelled to a great extent on activities of that order.

Chafing from friction, especially heels from ill-fitting socks or shoes, has to be watched ; boracic acid powder, or greasing with vaseline, is recommended. Vermin must be avoided. The threat of exclusion often means securing previous cleansing.

Accidents from falls, slippery grass, or cuts of various kinds may happen. Any possibility of illness exists, indigestion or gastritis, temporary debility and faintness, one cause of which is dilated heart, are not uncommon. Elementary school children must not continue at any exercise if they shew signs of being fagged. Even a short rest is useful.

All these things have to be watched, and a doctor should be

seen at once in a case of doubt, the Authority being responsible for the first fee at least, in every case.

The beginnings of various diseases—meningitis, diphtheria, scarlatina, and enteric fever—have all occurred. Whatever the illness, there must be discretion and reticence so that no alarm is caused.

The Authority should arrange that no responsibility for cost falls upon teachers in any case of accident or illness.

CHAPTER XV

TONSILS AND ADENOIDS

Grouped around the structures named as tonsils and adenoids are a whole series of other mechanisms and arrangements. As in so many problems concerning children, the edge of the unknown becomes visible almost at once. On many points ignorance is profound. External description has to satisfy whilst awaiting the discovery of deeper machinery.

The story of the development and working of the lymphatic tissues is scarcely touched—it is yet extremely fragmentary; but it holds the key of a future prophylaxis still beyond attempt. The elucidation of the comparative anatomy and physiology of the tonsil has been begun by Hett and Butterfield (*J. Anat. and Phys.*, 1908).

The mere form of mathematical expressions for rates of growth in infancy and childhood shew unknown causes working at enormous pressure at first, and rapidly decreasing, whilst other factors come into prominence and then disappear. These superficial indications suggest chemical reactions. The study of the growth of tissues *in vitro* has promise. It shews the presence of ferments, hormones or vitamin-like bodies in young tissues, absent in older, giving powers of growth and of resisting adverse environment.

The lymphatic glands which act as a kind of blood refinery in their action on toxins and waste products in body fluids, passing through them on their way to the blood, possess powers in somewhat the same age relations, with possibly a temporary increase at puberty, then a trailing off for the rest of life.

The whole lymphatic system is relatively larger and more powerful as it has more to do in the growing period and the younger the child.

The chief portals of entry to the body are through the digestive and respiratory channels, and it is cranial parts of these, nearest the external world, which are particularly guarded.

The respiratory channel has its thick mucous epithelium, with the cilia, moving quite substantial bodies outward, whilst materials not thus removed remain, penetrate, or are absorbed and are dealt with by masses of lymphatic structures that are scattered immediately under the surface and particularly around the pharyngeal region. The mouth has also to be guarded, for

here the teeth and peridental structures are places of diminished resistance.

Where there is much long-continued slight irritation from foreign substances, a contaminated atmosphere, or dust, the usual response in many children is hypertrophy, especially of tissues about the posterior ends of the lower turbinate bones, masses of lymphoid tissues on the roof and posterior walls of the nasopharynx, and laterally in the fossæ of Rosenmüller, just behind the Eustachian openings. These tissues, when hypertrophied, were first described by Meyer of Copenhagen (*Trans. Medico-Chi. Lond.*, 1869) as adenoids. Included also in the lymphoid tissues are the faucial tonsils.

History and Anatomy of the Tonsils.—The tonsils are very important and a clear vision of their anatomy has practical bearings for the school doctor. Dr. Milne Dickie of Ottawa describes them well (*School Hygiene*, 1921. 183).

"Situated on either side of the throat between the anterior and posterior pillars of the palate are organs of structure somewhat similar to lymphatic glands, with certain important differences. They are on a free surface and merely covered by epithelium, whilst bounded on their deep surface by a strong fibrous capsule, continuous with the fibrous layer of the mucous membrane of the mouth. The surface epithelium dips at intervals into the substance to form deep pits or crypts, which extend in many cases right to the capsule. The epithelium, stratified on the surface, becomes thinner and thinner, till in the bottom of the crypts it is merely one layer of flattened cells. Immediately under the epithelial layer is the lymphoid tissue, similar in structure to that found in the spleen or lymphatic glands. This is supported by strong trabeculæ of fibrous tissue, which extend inwards from the capsule. Outside the capsule is some loose areolar tissue, and outside that again the muscles of the palate and the constrictors of the pharynx. The blood-vessels and nerves of the tonsil reach it mainly through its lower pole. At the upper pole and partly hidden by the anterior pillar is the supratonsillar fossa, an extra large crypt with secondary crypts opening into it. It is entirely enclosed by the capsule of the tonsil, and of surgical importance as the place through which a quinsy or peri-tonsillar abscess generally evacuates itself. The tonsil is connected by several lymph vessels with a large lymphatic gland at the junction of the common facial and jugular veins. At birth the organ is small, but during the first three years the lymphoid tissue proliferates, and the tonsil increases considerably in size. Normally, after the sixth year it begins to shrink. At puberty it should be quite small, and in adolescence the space between the pillars should be a more or less smooth hollow with merely a trace of lymphoid tissue."

The importance of the tonsil lies in infection of the crypts, often filled with broken-down caseous material, and infested with a variety of micro-organisms. Sometimes there is little suspicion till the tonsil is removed, when septic masses may be found deeply at the bottom of the crypts, where the epithelium has thinned out to a single layer.

The tonsil may project enormously, and even touch its fellow, or may appear flat and project in the opposite direction into the peripharyngeal tissues. It may seem quite small on inspection, and yet be enlarged, hidden, and septic.

The bulk of the structure of the tonsil is packed with round cells which are active agents in digesting and destroying foreign and waste matters. In this process, too, especially where germs or their toxins are dealt with, tonsils probably aid in the acquirement of a considerable amount of immunity.

As with the rest of the lymphoid tissues, the vigorous period of the tonsils is in the earliest years of life. They should atrophy steadily with appearance of the second dentition and be mainly fibrous by ten years of age.

In an analysis of 1243 children aged 4 to 13 years, in the Chelsea elementary schools, Yearsley found the percentage with adenoids in each year of age respectively 23, 31, 42, 44, 52, 41, 33, 35, 43, 30. The greatest prevalence, 52 per cent., between the ages of 8 to 9 years is the age generally recognized as that at which adenoids make themselves most evident (*Brit. J. of Child. Dis.*, 1910. 61 and 97).

Beyond the pharyngeal ring of lymphoid tissues, sometimes called Waldeyer's ring, is the chain of cervical glands, the second line of defence, where micro-organisms which have passed the first barrier are usually held up, or their toxins destroyed.

The whole area of nasal passages and sinuses, Eustachian tubes and middle ears, and mouth and jaws, may contribute irritation, either massive or chronic, and cause acute inflammation and abscess, or the more common chronic hypertrophy.

Acute inflammations depend on a sufficiently large dose of the toxic cause, and are therefore rare except in the case of the tonsils, where various forms of streptococci, or the exanthems, may cause quinsy, some forms of which are very serious in the protracted debility resulting.

Chronic hypertrophies may cause immediate symptoms from pressure due to swollen structures blocking the passage of air, or causing accumulation often accompanied by decomposition of secretions, or from interfering, for instance, with proper growth relations of the palate. Deviation of the septum of the nose, which not rarely causes trouble in later life, may sometimes be a result as well as a cause of early nasal obstruction.

The symptoms are at first intermittent, by night not by day, depending on conditions of congestion. Usually the lowest nostril at night becomes blocked, especially in damp weather. Leonard Hill has demonstrated how evident the tendency to obstruction becomes with a hot, damp atmosphere.

A test of relative degrees of obstruction when incomplete is to use a cold polished metal plate held horizontally below the nose in breathing, and judge the stream of air passing from the amount of condensation of the vapour on the plate.

The first result of want of drainage is a chronic accumulation of secretions in the nasal passages or sinuses, and with this a lowered immunity starting a vicious circle of catarrhal infections. Another is the mechanical pressure of adenoids or swollen mucous membrane whereby the Eustachian tubes are blocked, and ventilation of the middle ears hindered. The seriousness of this is to be considered in relation to hearing, and secondary deafness is one of the signs of pharyngeal obstruction by adenoids. Liability to nasal sinusitis has also been recently described as one of the results of vitamin A deficiency (*J.A.M.A.*, 1923. ii. 828).

Where nasal obstruction is considerable, mouth breathing becomes established. Mouth breathing is one of the accessory means of air intake, which should never be needed except under extreme air hunger as after sustained effort in a violent run. The mouth breather may have developed this habit in some temporary cold or catarrh which has long passed away, whilst the habit remains. Probably half the number of cases of chronic cough in children up to the end of primary school age is due to throat reflexes chiefly from enlarged or inflamed tonsils, less frequently with adenoids, ear troubles, and sometimes vomiting may be associated with the chronic cough, bronchitis in mild degree may also follow, but it alone accounts for a considerable number. About half of the mentally defective children are mouth breathers without having nasal obstruction, the original cause having become relieved without the re-establishment of nasal breathing.

Etiology.—Causes of pathological changes in these lymphoid structures, which should be atrophic ere the middle of school-life, are mainly infections. One child in a family may resemble its mother and like her have adenoids, whilst another may resemble the other parent and have no adenoidal trouble. Some degree of heredity must therefore be allowed. Children are sometimes almost born with adenoids. The common colds and catarrhs, possibly use of the dummy teat, account for many cases. Once the irritation begins in a susceptible child the circle easily becomes established.

Leathart, of Liverpool (*B.M.J.*, 1920. i. 217), considers chronic infection of lymphoid tissues of the pharynx as an infectious disease

which is commoner in school than in non-school children, and spreads through a family. There is an element of truth in this low-grade infection, but the rest of his ideas are hardly borne out by clinical experience. Just as likely is it that some thyroid insufficiency predisposes to infection, and French writers have spoken of a thyroadenoidal syndrome, including in its manifestations the gastro-intestinal catarrh occasionally associated with adenoids, the mucous disease of Eustace Smith.

Sprague (*Boston Med. and S.J.*, October 11, 1906), in an analysis of five thousand operative cases, concluded that neither climate, city nor country life, bottle or breast feeding, heat or cold, tubercle, syphilis, or rheumatism played any noticeable part in etiology.

Damp soil was excluded by analysis of various parts of Kent in 1912, where the same observer over three very different geological formations found a practically equal prevalence of adenoids.

Prophylaxis consists in avoidance of catarrh, and maintenance of high degrees of immunity, by a healthy life of exercise and feeding. Goldthwaite states that his lean carnivorous type is most prone to hypertrophy of tonsils, adenoids, and appendicitis.

Education in good personal hygiene by precept and practice, should be part of the earliest teaching for every child in the State. The practice of breathing exercises by infants has a useful purpose, but not the teaching of mouth breathing by which singing instructors and teachers of physical exercises often mar their work. Handkerchief drill should be an invariable practice in the lower standards. Further ideas, not only of maintaining nasal efficiency, but of actual remedy in early stages, have been put forward by enthusiasts who advocate sneezing practice.

Sneezing Classes.—Interference with the drainage of the nose, either by malformation or merely by reactive swelling, and accumulation of secretions may set up considerable catarrh, so that masses of mucus block the channels and sinuses ; sneezing out to deplete the membranes has therefore been advocated as anti-catarrhal prophylaxis.

Dr. Isabel Ormiston (*Lancet*, August 24, 1918) drew attention to the method of Mrs. Handcock in Tasmania for preventing adenoids by promoting sneezing, through the irritation of the septum naris, by dusting a powder of iris root and soap on it. A considerable flow of lymph and much sneezing out of mucous discharge results. It is important merely to make the children sneeze out, never snuff up, or not to sneeze with pinched nose, which would drive material into sinuses or Eustachian tubes. The powder, too, should be dusted into the nostrils, never snuffed up.

Dr. Gertrude Hickling (*B.M.J.*, 1920. i.) investigated this in a class at Manchester, and found many relieved and others improved ; and Dr. Lepage, who kept the class under observation, thought

that the method was worth continuing. Dr. Octavia Lewin has advocated the method strenuously (*School Hygiene*, 1921. 95). After enquiries, Dr. C. J. Thomas concluded that it was a useful educational method, but as a treatment the game was not worth the candle. A good description of a class is given in *Child Life*, May 1919.

The use of sternutatory powder for a child with a blocked nose might be supposed to involve danger to the middle ear. Apparently this is avoided by preventing voluntary efforts on the part of the child and only permitting expulsive ones. The cleansing of the nose is wholly good, and frequent use of the pocket-handkerchief should be obligatory, so that no child is seen with strings of mucus excoriating its upper lip. The sneezing classes in the form suggested appear, however, unnecessary as a definite addition to school treatment arrangements.

Diagnosis.—The diagnosis of conditions of hypertrophy of these adenoid structures should be made as soon as possible, so that surgery may give relief ere damage is done.

The condition of tonsils can be determined in great measure by inspection, although actual size is no real criterion. The follicles may be obviously in offensive condition, plugged with visible detritus.

American writers attach importance to the dull red appearance, which is taken to indicate necessity for removal, also to a strip of dull redness from an eighth to a quarter of an inch broad along the anterior pillars of the fauces parallel to the anterior border of the tonsil as suggestive of a chronic inflammatory condition. The tonsil may, however, be flat, not much projecting and yet considerably enlarged subcutaneously, submerged among the other tissues.

When the tonsil is not apparently much enlarged there may be a history of sore throats or even evidence of other remote effects which suggest danger of chronic toxic poisoning.

Mechanical Symptoms from Enlargement and Pressure.—The presence of adenoids can be determined by inspection. Formerly some surgeons used the finger to palpate them, a method which there is no excuse for using nowadays, as if necessary they can be inspected by one of the post-nasal specula. Lennox Browne attached importance to a small area of swollen mucous membrane on the floor of the nostril as very commonly seen with adenoids. Mouth breathing is the commonest symptom. Many of these children snore at night. The membrana tympani will often be found pink and indrawn. The bad cases will have also nasal discharge and the adenoid facies with collapsed alæ nasi, shortened excoriated upper lip and open mouth. Cases with enlarged tonsils may be assumed to have also enlarged adenoids, on the other hand there may be great masses of adenoids with buried tonsils. The

writer has seen a case of cleft palate with masses of adenoids, but no tonsils visible.

The lateral masses in the fossa of Rosenmüller often account for intermittent earaches. Any child with earache in the first half of school-life probably has adenoids. There is often want of development of bones of the upper maxilla from absence of air pressure, and commonly superior protrusion of the teeth. The mechanism appears to be nasal obstruction causing substituted mouth breathing. The diminished intra-nasal pressure compared with the intra-oral in young children leads to the collapsed alæ, flattened bridge, and arched palate. With the obstruction to breathing intra-thoracic pressure during inspiration being low, the soft cartilages yield, giving a Harrison's groove, and the prominent keeled sternum.

Diagnosis should be comparatively easy. The Dutch teachers in 1904, at the instance of Guye, made returns of all their children, and put down 6·5 per cent. as having adenoids. The more careful the examination the higher the numbers found. P. M. Yearsley in 1911 noted 3 per cent. of elementary scholars as obvious, but careful examination he found raises this to 30 per cent., and it is probable that four-fifths of the cases are not suspected till serious results are established. H. P. Newsholme found 7 per cent. in Croydon schools, but, as he states, the proportions have now been much reduced by early treatment (1925).

In New York, of the cases selected for operation by the medical inspectors, when completely examined, 95 per cent. were operated on, so that school doctors hardly err in returning too many as having adenoids.

Apart from these direct evidences are a group of other effects. The reflex nervous effects of pressure among structures of the face are many. Mental peevishness, dreadful dreams, night terrors, bed wetting, grinding of the teeth are all common in association with adenoids. The last is assigned as the only obvious symptom in 10 per cent. by Bakker (*Rev. de Laryng.*, 1924. 708).

Benjamins (*Laryngoscope*, 1922), analysing 1791 cases, noted: snoring, 1085; impaired hearing, 908; grinding of teeth, 618, and enuresis, 462.

Aprosexia.—In association with adenoids is a condition first described by Guye, of Amsterdam, as aprosexia.

For some reason existence of hypertrophied lymphatic structures in the naso-pharyngeal region, adenoids especially, is associated with this peculiar mental condition. Formerly, such children were frequently submitted for examination as suitable for special schools for the mentally defective, and the condition used to be described as spurious mental defect. Apperception is greatly lowered, and attention cannot be maintained. The nutrition of the frontal areas

of the brain seems affected, whether by accumulation of fatigue products from interference with lymphatic drainage, or by toxins circulating in the blood, or in what way, it is still impossible to say. The condition is remarkable for variability. The cases described by Guye, and many representative cases, are quite sharp and intelligent at times, but they are as often dreamy, absent-minded, and wool-gathering.

The variations depend on the condition of throat and nose, and are more obvious when the structures there are swollen from catarrh, or from humidity of the weather. These children are always mouth breathers, and often have other sequelæ of the adenoids from which they suffer, not the least of which is a character in later life, timid, fearful, and doubting. The clear-cut cases, as described by Guye, are not common.

Yearsley gave 5 per cent. of London cases as shewing the symptoms, but Benjamins gave for his Utrecht children, out of 1791 with adenoids, 566 as having aprosexia; Crowley found 28 per cent. (*Pediatrics*, 1897). He, however, also distinguishes true aprosexia from dullness due to defective hearing. Formerly the second half of primary school-life shewed the worst cases; now the action of Educational Authorities has shifted the prevalence to much younger children, who undergo timely treatment. To judge from statistics, all degrees of the condition of deafness or obfuscation may be included under the term. In slighter cases recovery appears to take place, and they leave school apparently well, save for a little catarrh; but in others, slow changes are still going on, to appear as the chronic dry catarrh with a little tinnitus and deafness half a dozen years later, often followed by serious impairment of hearing in early adult life.

Priestley, in Staffordshire schools, analysed 13,337 unselected children, and 7·1 per cent. were dull and backward. Of the mouth breathers, 10·7 per cent. dull and backward. Taking the 608 mouth breathers, 353 not deaf, had 6·5 per cent. dull; whereas 255 with some deafness had 16·5 dull. He concluded that aprosexia was mainly due to deafness. Variable deafness has a great deal to do with the psychological effects noted. An interesting study of the adenoid child in relation to posture by Lucy Wills and Joan Warwick (*Quart. J. of Med.*, January 1924) decided that with inflammatory adenoid states the posture is normal, but with chronic hypertrophy, muscular hypotonus results in lordosis and a pendulous abdomen. Over four-fifths of the cases could be diagnosed on posture.

A quarter of a century ago, Lane pointed out the considerable effect on posture.

The chronic congestion affects the Eustachian tubes, and discharging ears or chronic middle ear catarrh often refuse to clear

up until the throat has been cleared. Probably more than half the cases are a secondary result of adenoids. So, too, many cases of phlyctenulæ recur time after time. Nearly the first thing the writer learned when practising as both eye and ear surgeon, was that the proper treatment for phlyctenular ulcers was often removal of adenoids.

Strumous children with photophobia are nearly always stuffed with adenoids. H. P. Newsholme notes the greater frequency in poor districts, and thinks over-crowded homes a factor in production.

The only mistake likely to be made is that chronic hypertrophic rhinitis or a nasal spur may be adenoids.

Headache is often associated with these nasal conditions, and if the mistake is made removal of adenoids affords little relief.

Septic and Infective Results.—Adenoids are covered with a considerable thickness of epithelium, and acute inflammation from infection, although it does occur, is rare. In connection with the exanthemata or diphtheria, acute inflammation may have the most serious and destructive results.

Sore throat was so important as an early sign of various infections that one of the earliest steps under the London School Board was refusal of re-admission, when diphtheria was prevalent, without a certificate of freedom from infection. No child with any kind of sore throat should be allowed to remain in attendance, until well, and if either diphtheria or scarlatina are prevalent, a medical certificate of freedom from infection should be required.

Sore throat not amounting to acute tonsillitis may be the commencement of a rheumatic attack, which above all other treatment requires rest in children. Typical is an outbreak of hundreds of cases of anomalous tonsillitis, with a few cases somewhat resembling scarlet fever, traced by H. P. Newsholme to a milk supply (Croydon, 1924).

Acute tonsillitis is more frequent, the invasion of the tonsillar crypts being easy from the thinning out of the epithelial layer. Sepsis in the tonsil is usually deep seated.

The bacteriology of the tonsils embraces a large literature and is highly technical, beyond the range of this book.

The examinations of tonsils carried out in Liverpool by N. Wall in 1922 may be taken as an example. She made 170 inoculations from 120 patients. Three of the guinea-pigs became tuberculous (2·5 per cent. in none of which was tubercle suspected), diphtheroids were found in 24 per cent. tonsils and 9 per cent. adenoids, meningococcus 5 per cent. tonsils and 2 per cent. adenoids ; whilst pneumococci were found 40 per cent., streptococci 80 to 90 per cent., micrococcus catarrhalis 84 per cent., and bacillus coli 10 per cent. Adenoids shewed least micro-organisms and the depths of the tonsils most.

As regards tubercle, inoculation methods demonstrate the tonsil is a station of access, mainly for the bovine bacillus. Bacilli are not commonly stained *in situ*.

The writer has sectioned and stained many tonsils and adenoids and never thus found actual tubercle bacilli, although acid fast bacilli of the smegma type are to be found occasionally.

On the other hand, in the Derbyshire school clinic, when many cases with enlarged lymphatic glands were referred for tonsillectomy ; scrapings, stained as if for sputa, gave results from which it was inferred that 45 per cent. were infected with tubercle bacilli (Derbyshire Report, 1920). It is probable that in this infection of young children raw milk may play a part.

The various streptococci are important organisms, as the tonsil may become a septic focus of a chronic nature establishing all the varieties of disorder now associated with the toxic syndrome. Rheumatism, chorea, and carditis are common results.

The original case from which Poynton demonstrated rheumatic infection was a case of tonsillitis setting up carditis.

Tubercular cervical glands are generally tonsillar in their origin, septic infection preparing the way for the ubiquitous tubercle bacillis to settle and flourish. Acute tonsillitis has other remote results. Acute pneumonia, septic meningitis, to which the writer was directed early in his experience, are fortunately rare terminations, but he has met acute thyroidal troubles with exophthalmic goitre in young adult teachers several times after tonsillitis, and among women teachers a history of tonsillitis is not uncommon in goitre cases. A condition of prolonged cardiac debility with rapid pulse lasting from two or four months is another sequel which one must be prepared to meet.

Where scarlet fever becomes prevalent, it may be preceded for a few weeks by a widespread series of sore throats, which, however, it is impossible at the time to assign to scarlatinal poison. Recently the Dicks have associated a form of streptococcus hæmolyticus with scarlatina and shewn that this organism with scarlatinal reactions is comparatively common in tonsils.

Diphtheria and diphtheroids are notorious for persistence, and carriers can sometimes only be "cured" by tonsillectomy. On the other hand, there is no satisfactory evidence that tonsillectomy is a definite prophylactic against acute rheumatism.

The Question of Operation.—Once the presence of adenoids had been ascertained, the family doctor would formerly often advise their being left alone and the child would grow out of them. In occasional cases this is true. As the pharynx enlarges, the adenoids may cease to trouble, but the risk is enormous.

Dr. Kate Cowe in Bootle inspected 213 leavers in 1919 who had been noted with tonsils or adenoids as entrants or in early inspections.

One-third had the condition unchanged, one-fifth were much worse, and less than 9 per cent. had improved. In addition a number noted as free from symptoms now presented them as leavers. These were 47, equal to about three times as many as had improved.

One may therefore say that it is ten to one against an entrant with tonsils or adenoids improving before leaving school, and even if naturally outgrown, the individual may carry the adenoid facies through life.

Formerly it was said that enlarged tonsils and adenoids were secondary, that their removal was merely treating symptoms, and that the primary causes should be sought in the mouth or nose. These causes should be eliminated, but there remains the risk of infection and inflammation, risk of pressure setting up changes that perhaps ten years later will eventuate in chronic dry catarrh of the ear and steadily increasing deafness, and risk that an attack of exanthemata or even an acute cold may result in destruction of the middle ear.

Most of the cranial operations done in children originate in neglected adenoids. All suggestions of breathing exercises or respiratory development are vain in face of organized masses of tissue. They are only justified when serious contra-indications to operation exist. Paints, brushings, gargles, nasal injections are trivialities, and a waste of time, concerning adenoids.

If adenoids are found, and any ear symptoms, however slight, are present, operation requires doing thoroughly, and especially are the fossæ of Rosenmüller to be cleared, after the main mass in the roof of the pharynx has been removed.

Some children shew the effect of operation for weeks, have loss of weight and suffer from shock. The debilitated, pallid child requires some building up, first by iron and oil. Possibilities of further infection have to be foreseen.

Although G. R. Gibson, in a statistical study (*Med. Off.*, August 11, 1911), found no relation between dental caries and enlarged tonsils, dental treatment sometimes obviates operation. In any case, to diminish septic risks oral preparation is required. If there is discharge from an ear an effort should be made to remedy this first, but it is not a contra-indication to operation, which is often necessary before cure of a discharge. With children who are asthmatics, bleeders, or likely subjects of status lymphaticus, the risks of operation will probably be too great to be undertaken. Witherbee in New York uses small repeated doses of X-rays with success instead of surgery.

Sometimes the doubt as to operation is with regard to tonsils. Much enlarged tonsils almost connote adenoids. They may give rise to difficulty in swallowing. Where cervical glands are enlarged the tonsils are likely to be septic foci of infection, almost certainly

when tuberculosis is in question. Where the crypts are full of material, or it can be squeezed out, infection is probable. Pitted and scarred tonsils are more dangerous than merely enlarged. In the case of tonsils, removal is needed not so much on account of mechanical obstruction, nor because they are an open door for infection, but because they are actually dangerous as a septic area to be eradicated only by operation.

There may be a tender gland behind the angle of the jaw, or recurrent feverish attacks which suggest sepsis. Under these conditions breathing exercise as sole treatment is dangerous folly.

Tonsillectomy is always to be preferred to tonsillotomy for, although the last is less severe an operation and less open to immediate septic complications, it may not do what is wanted, and occasionally is followed by aggravation of toxic symptoms or extension of sepsis through the remnants of the tonsils left.

It is as well to avoid operations during epidemics or prevailing sickness. The writer once saw a scarlatinal rash appear within 15 hours of his operation on a boy, who soon had destruction of the middle ear rapidly following the local sepsis which ensued. Many cases of acute rheumatism are reported as following on tonsillotomy. Poynton refers to one which died of carditis six months after the operation.

The removal of tonsils and adenoids is now practised in tens of thousands, and often done badly. In Bedfordshire, enquiry in 1921 shewed that 12 per cent. of the leavers had been operated on. The operation is always to be considered a major operation on a child. Preparation must be made accordingly. The anæsthetic gas, or gas and ether, has of late years been largely replaced by ethyl chloride.

There is much danger in chloroform ; in private it is convenient, but it can only be used with fear and trembling. Status lymphaticus is more common in these adenoid cases than in other children.

The child should never in any circumstances return home until 36 to 48 hours after operation. Watson Williams shewed that with the greatest care, morbidity, chiefly otitis, was four times greater with out-patients than in-patients (*B.M.J.*, 1920. ii. 887).

The operation of tonsillectomy by enucleation of the tonsil was described by Celsus, two thousand years ago, but has only been revived in the past twenty years, as the pathology of tonsillar infection and sepsis became evident.

Sluder's method of using a fairly blunt tonsillotome reversed and twisting it out is best for children, in whom no dissecting should be required. There have been fatalities. The result of anæsthesia is the commonest cause, but cases have died from hæmorrhage.

The writer heard of a child whom he had never seen, dying

the same afternoon at a railway station eighteen miles from where he had been operated on.

A case is noted in a medical officer's report in 1921 as dying three days after operation in hospital, from inhalation pneumonia. This cause has been several times reported in America. The tonsil was recently inhaled in an American case, but fortunately recovered and the child was resuscitated. Propaganda against the operation, largely based on the scandals of the time when children, still bleeding from the operation, returned home in tramcars or were refused admission to public conveyances, have been very steadily maintained.

Many parents have objected to operations. There has been much undue fear of hæmorrhage in tonsillectomy. It is only to be really feared in adults after repeated tonsillitis, but children should lose as little blood as possible.

In his careful review of adenoid conditions, H. P. Newsholme estimates that the municipal clinic has reduced the numbers in school needing operation to one-third, i.e. about 2 per cent.

The Legal Bearings.—Certain magistrates refused to convict under Section 12 of the Children's Act, 1908, where parents objected to have a girl of 13 operated on for adenoids. The parents did not think it necessary and did not believe in operation. Three judges in the King's Bench Division, November 14, 1913, held that the defendant had had the need of an operation brought to his notice, and on the facts the magistrates should have convicted, so the case was referred back.

In 1924 the Atherstone magistrates insisted on the operation being performed for an eight-year-old child, giving the father—himself deaf—two months to have it carried out.

In 1914, where a five-year-old child was operated on by an association of medical practitioners and had chloroform spilled on its cheek causing a scar, the jury found that there had been no negligence on the part of the anæsthetist, but even if there had been, Mr. Justice Lush said that the local Education Authority would not have been liable, as they had discharged their duty under the Act (Section 13, 1907) by arranging with competent medical men to perform the operation.

Post-operative Conditions.—Many of the cases operated on in the days of tonsillotomy gave brilliant results, probably chiefly from clearing of adenoids. A careful operator who saw to it that there was well-established nasal breathing ere he parted with his patient was generally satisfied with his work.

Nowadays a skilled operator should have excellent results in four out of five cases. Faulder, who studied the whole question from the public health standpoint (*Lancet*, 1910. i. 1746, and ii. 21 and 97), put the good results at not less than 90 per cent. (*B.M.J.*, 1913. i. 1324).

Pearson (*L.C.C. M.O. Ed. Report*, 1911. 97) made enquiries on 400 cases operated on over a year previously. In 59 per cent. the result was unsatisfactory; and grouped in the satisfactory were 12 per cent. still mouth-breathers, and only 29 per cent. wholly satisfactory. Included as unsatisfactory were 27 per cent. of all who had turbinate hypertrophy, 15 per cent. deviation of the septum, 18 per cent. adenoids, 13·5 per cent. tonsils, and 5 per cent. aural discharge. He palpated adenoids, finding them laterally and mainly on the right side.

School clinics, special hospitals, and private operations gave about 52 per cent. (50 out of 90) good results. The large general and children's hospitals gave 32 per cent. (or 108 out of 337) satisfactory.

Kaiser's results of 5000 tonsillectomies shew about 80 per cent. giving good results (*J.A.M.A.*, 1922. i. 1869). He has recently published a comparative study of 1200 cases followed for three years after operation, and of 1200 similar cases recommended for operation but refused by the parents. Save for this last distinction, which suggests heedlessness in other respects, the two groups were as strictly comparable as statistical groups usually can be. He found that for tonsillitis and head colds the operation is a decided protection, it only slightly affects enlarged cervical glands, and tonsillitis may be considered as responsible for a considerable proportion of these. There was no decrease in rheumatic or cardiac cases in the two groups, and the acute zymotic diseases, whilst possibly lessened in severity, were still equally prevalent. Malnutrition was definitely reduced among the operated group (*J.A.M.A.*, 1924. ii. 33).

Meddlesome post-operative treatment by gargles or douches should not be needed. The ears may have to be watched to prevent possibly acute otitis.

The commonest failures seem to be due to insufficient removal of adenoids, particularly the masses behind the Eustachian openings, which are those likely to be risky for hearing. There is also the neglect of nasal conditions, turbinate hypertrophy, and the occasional raspberry-like mass on the posterior end of the inferior turbinal. In addition, if a good result is to be looked for, breathing exercise and the establishment of nasal and prevention of mouth-breathing is almost as necessary a part of the treatment as the removal of adenoids.

A careful examination before, and a year after operation, on 666 cases at Leicester, shewed that vestiges of tonsils remained in only 3 per cent., and there was a 32 per cent. reduction in numbers of children with irregular attendance, 34 per cent. in those retarded, 45 per cent. in number noted as hard of hearing, and 23 per cent. less of those who were dull. There was considerable improvement

at all ages in the rates of growth in height and weight of both boys and girls as compared with rates of growth given by Tuxford and Glegg (*Med. Officer*, February 23, 1924. 75). Vestiges, however, may set up all the signs of a chronic local sepsis, ill health, want of energy, chronic nasal discharge, and sometimes cough. In some cases where obscure signs have suggested sepsis, operation on the tonsils has had immediate relief. This is common in teachers where neuritis, rheumatism, and even wryneck and similar myositis has almost at once cleared up after successful tonsillectomy. William St. Lawrence, after a study of 85 rheumatic children, followed up for three and a half years, concluded that tonsillectomy was the most important measure at present available to prevent

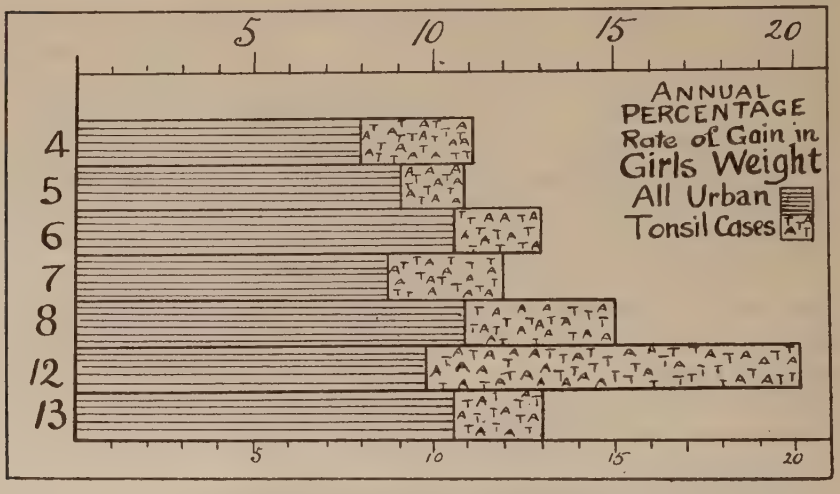


FIG. 56.—EXPERIENCE FROM LEICESTER SCHOOLS.

recurrence of rheumatic manifestations (*J.A.M.A.*, 1920. ii. 1035), although Poynton does not take this view. Possibly early cases gain more from operation than more advanced ones, but without some signs of infection operation is not called for as a prophylactic. A hundred new cases of chorea had 62 with history of tonsillitis, of which 18 had had operations (Newlin, *Pennsyl. Med. Journ.*, June 1914). Poynton regards tonsillectomy as a mistake in rheumatic children if there are no evidences of tonsillar disease; and Guy's Hospital workers found no support for tonsillectomy as a prophylactic in their analysis of cases of acute rheumatism (*B.M.J.*, June 16, 1923).

In 25 cases of rheumatic fever where tonsils were removed, recurrence was noted in 5 (Crowe, *Johns Hopk. Bull.*, January 7, 1917). In 23 cases of chorea similarly recurrence occurred in 8. One patient who had never had chorea developed it after tonsillectomy.

Respiratory exercises alone, even in doubtful cases, can never be satisfactory as a general school treatment. Experience shews that the persistence and care needed put them out of court.

Cases where good nasal respiration is not developed after operation in spite of exercises, often are wanting in coaptation of teeth, or with malformation of upper maxilla. The short upper lip of the adenoid face may give a hint of this, and make it possible to judge a mouth-breather as not likely to find much relief from operation (McClanahan, *Arch. f. Pediat.*, 1913). For most children very active, even violent games, are the best means for thoracic orthopædics.

Only general statements can be made as to the effects on nutrition and growth. As at Leicester, the general impression is of good results ; and, as already noted, it was much improved in Kaiser's operated group.

Some enquiries have been made as to the effects mentally. The obvious, and in some cases brilliant, results, with those shewing aprosexia, have perhaps led to extravagant expectations.

Children tested with the scales of psychological values now available, have failed to demonstrate any significant improvement in intelligence quotients, as against control groups. Gladys M. Lowe has reviewed the subject in the *Psychol. Clinic*, iv. May 1923, and found that a year later there was no material gain. She quoted Rogers (1922), Terman (1917), Cornell (1912), and McPhail (1920) as in agreement.

The Public Lessons Taught by Adenoids.—It is not sufficient that provision is made whereby a third of the children who present pathological conditions among the large numbers with enlarged tonsils and adenoids can be medically or surgically treated in a satisfactory way with the minimum expense of time and trouble. While one-third of the children in the school present conditions which represent a struggle against the factors of ill health, the causes must be sought out and removed as a public task. In the widest sense of the term they are mainly nutritional. In this matter our schools and public health agencies, blighted by C.O.S. doctrines, have been almost marking time for many years. It is not a mere academic enquiry, but a fundamentally important one, which also lies at the roots of tuberculosis and other causes of chronic debility. There are large numbers of germs of comparatively low pathogenic powers, against which only temporary immunity seems to be acquired. Some of these, as will be seen later, are the primary agents in heart disease, the greatest crippling and fatal disease group in middle life. The common " dirt " inflammations of the eyes and ears, and fungoid rashes of the skin so evident among debilitated children and invalids, afford other examples ; catarrhal attacks, the common cold, the micro-organisms of

which cause an enormous diminution in health annually and loss of millions of working hours, can be resisted easily in vigorous health. The germs are so constantly present that any slight departure from a condition of resistance, a few minutes' chilling, a slight attack of indigestion, will give the opportunity for invasion. Increased living room must be found not only in houses but in cities, and, above all, in our overcrowded elementary class-rooms. The only remedy is to take hostages for conditions of good health by compelling every child in the community to put in half a dozen years in the primary school. Then healthy class-rooms for all will be ensured.

The want of personal hygiene, the result of educational neglect, contributes materially to permanent damage of vision and hearing from slight dirt infections. It is also a great factor in catarrhal conditions of the nasopharynx. The mentally defective children learn mouth-breathing in excessive numbers because the natural channels are neglected. The children who do not use handkerchiefs are more often mouth-breathers than others. Breathing exercises where both inspiration and expiration are through the nose should be an essential part of infant school work. Handkerchief drill is to be thought of in the earlier standards. The inculcation of cleanliness beyond the level of louse hunts and compulsory cleansing schemes ought to be an educational part of the school work, and when the want of cleansing opportunities and the need of the tonic influence of bathing are properly appreciated, school baths will be insisted on as part of the prophylaxis against the lymphatic debility which shews ultimately in adenoids or even tuberculosis.

The reserve powers of the child have to be cultivated. Free exercise and fresh air means the need of playground areas beyond those attached to the schools. The children will have to be enticed into playgrounds in the sunshine if they are to live in towns and maintain health.

Room to live and play in is needed if the evil results of adenoids and their effects are to be avoided. The expenditure of any public money on the health of children is of far greater national importance than its expenditure on the health of adults. The most important persons to be cared for by the State are those under three years of age.

CHAPTER XVI

TUBERCULOSIS

Surgeon-General Gorgas, the American sanitarian whose work made the Panama Canal possible, declared in the last year of his life, "The prevention of tuberculosis is the most important health problem in the country, in spite of all the work that has been done."

Its prevention is one of those sanitary problems not to be solved merely by care for its victims. The only scientific solution hits vested interests, and is hindered by the cupidity which sacrifices public needs to private gain. Tuberculosis indirectly costs millions of money annually, and is the cause of about half the inefficiency of the British working man.

In 1922 there were 69,259 new cases notified in England and Wales, and the deaths of 42,777 victims recorded. Newsholme, as the result of twenty years' work in Brighton, estimated the existing cases as three times the number of deaths.

For New York, Herman Biggs put it as five times the number of deaths. In the five years' observation of Framingham, Mass., the fatalities amounted to 21 per cent., confirming Biggs's estimate.

In this Framingham enquiry there was evidence that about 90 per cent. of the population were infected by tubercle, about nine times as many actual cases being found as had been previously revealed through ordinary sanitary control. Active cases amounted to 1 per cent. of the population. The inactive is another 1 per cent. (*Lancet*, 1924. i. 1243)

In a house-to-house survey of a Chicago district of 350,000 population, 165,700 were examined, and 14,282 found tuberculous, of whom only 4 per cent. had been reported. They included 1000 open cases and over 7000 were children (*Chicago Bulletin*, May 1918).

A large amount of indigency is associated with tuberculosis. Investigation ot the economics of tuberculosis in school children led a non-medical American author to describe it as a disease of poverty, and he concluded: "In the last analysis at this time the care and prevention of this disease is only possible when the following are properly provided: Nutrition, light, air, rest, and recreation" (G. E. Jones, *Ped. Sem.*, xxii).

In a similar strain, Woods Hutchinson, in his book *Conquering Consumption*, summarizes: "If the rich had more sense and the poor more money and both more public spirit, consumption would soon be a thing of the past."

Tuberculosis of Children in its Two Varieties.—Tuberculosis is an infectious disease, and, as with all these diseases, the result depends on the mass and rate of infection, necessarily variable for different individuals.

It occurs as a result of infection by the tubercle bacillus, of which several varieties are known. For clinical purposes, only the varieties common in bovine and human disease need consideration. In tuberculosis of human beings, either one variety or the other or a mixture of the two is found. Demonstration of the bacilli is the only certain test of active tuberculosis.

These two varieties are separable by careful tests. Short, squat, uniformly staining bacilli are generally bovine. The human variety has the long spore-bearing forms, but this is not invariable. Again, a form which grows rapidly on egg medium is probably human, but 4 or 5 per cent. of glycerine added to the medium stimulates human, but retards bovine, growths.

Theobald Smith pointed out that glycerine bouillon is rendered faintly acid by human, but alkaline by bovine varieties.

By such tests as these distinction is possible. The bovine bacillus is very virulent for guinea-pig, calf, or rabbit, whilst the human variety is almost avirulent for these animals. The bovine produces general tuberculosis, whereas the human varieties cause severe lung infections in the rabbit (Eastwood and Griffith, *Journ. of Hyg.*, January 1916. 257).

The cat, on the other hand, though susceptible to bovine, is said to be very resistant to human bacilli.

The bovine variety is not very virulent for most human beings, whilst the human is more dangerous. For some individuals the immunity resistance is so low that the human may appear highly virulent.

During an early period of infancy there seems almost complete immunity for a few diseases, such as measles or diphtheria. In the case of most others, due to germ toxins, the cells of the infant have at first scanty powers of resistance, which improve rapidly with age. A long period follows of comparatively strong resistance, especially during growth. After maturity, failure in resistance again creeps in with old age. The slightest scratch of the cornea may easily produce hypopyon keratitis, equally in the infant or the aged. It will only do so rarely and under special conditions, such as chronic alcoholism or nutritional disorder, in the school child, youth, or middle-aged.

Diagrammatically, the attacks of the two kinds of tubercle may

be similarly set out, although clinically such clear distinctions, as in hypopyon, are not possible.

The bovine bacillus has feeble powers of infection, exerted mostly in infancy, and scarcely at all in adult life. The human variety has all grades of reaction in different individuals, but in children, ere growth is complete, and whilst the lymphatic system is at the height of its functional vigour, the effects of the bacillus are usually limited and expended on gland infection. It is only after the glandular activity lessens with growth that those with hereditary tendencies feel the force of tubercle infection in early adult years.

Full age, with its frequent industrial fatigue, means another group of cases, and further on, as the body cells are becoming senile, there is still another group of extended infections. The younger the child, the more acute seems the clinical course of an advancing case, when the first line is overcome.

The original idea put forward by Behring (*Lancet*, 1903. ii. 1199) is still held by many. McNeil, for instance, "In childhood the seed is sown as latent tuberculosis; in manhood the harvest is reaped as phthisis" (*B.M.J.*, September 21, 1912). This doctrine is productive of wasted and misdirected efforts. The distinction between the two varieties rather puts this teaching out of court, so that the author, in 1910, felt justified in regarding the tuberculous cow as in some measure a help against phthisis.

It seems quite probable that the chronic slight tuberculosis, which in about 90 per cent. is the result of bovine infection, has some immunizing effects. It is doubtful whether, if all the tuberculous cows were slaughtered, there would be any noticeable decrease in deaths from phthisis.

Although tubercle bacilli have been found in stillborn infants, congenital tuberculosis is so rare that for school purposes it may be neglected.

Distribution of Tuberculosis in Children.—Post-mortem examinations have shewn an unsuspected proportion of tuberculous infections increasing with age.

Calmette's ophthalmo reaction for tuberculosis depending on a reddening of the conjunctiva of tuberculous persons from instillation of a solution of tuberculin, demonstrated the commonness of the infection. Calmette wrote (*L'Hygiene Scolaire*, 1909, 41): "This terrible malady is a veritable scourge of our public schools. Without doubt the majority of these children already touched by the bacillus have no other lesion than those non-contagious ones of the glands, for the most part curable by good hygiene alone."

Owing to risks of ocular damage, his test has now been replaced by Von Pirquet's cutaneous reaction, either obtained by inoculating a scratch with tuberculin, or by actual dermal injection. The tuberculously infected here shew a reddened patch of swollen skin

around the site of inoculation. It is a very delicate reaction, and has been amply supported by post-mortem findings.

Pirquet's results, confirmed by Hamburger, of the Children's Clinic in Vienna, shewed positive results increasing from zero in the suckling to over 90 per cent. before school age was passed. Hamburger speaks of tuberculosis as "a true children's disease." Just as everybody goes through measles, and this is acquired in childhood, so we can say to-day almost everyone acquires tuberculosis sometime, and mostly during the years of childhood.

Tubercle is like other infectious diseases, there are all grades of dosage and reaction to attack, but the normal school child in its approximately healthy surroundings may be regarded as practically immune to disease caused by the tubercle bacillus.

Many are infected, few suffer. In its usual dose, and usual results to the school child, the bacillus tuberculosis does not appear any worse than the bacillus coli, or the ordinary pus organisms. Tubercle seems omnipresent. Given slight traumatism of a joint, whether hip or finger, it may declare itself at the seat of injury, only to vanish if the tissues are given a sporting chance by physiological rest. The infection is frequently due to scanty bacilli, circulating in the blood, finding a suitable resting-place.

All this was not understood when medical control of schools started. The writer, who first went into elementary schools in 1893 in Bradford to supervise conditions of health, expected to find much clinical tuberculosis, but found it uncommon, and as regards diseased chest conditions extremely rare, less than $\frac{1}{2}$ per cent. of doubtful cases in the poorest schools (*Tuberculosis*, July 1900; *School Hygiene*, 1910. 14).

Ten years later, his colleagues, Drs. J. E. Squire and A. Gowdey, found in the schools of a London district, with a roll over 50,000, that the cases aged 7 to 14 years supposed to be consumptive generally were not, and that in unselected cases attending school 4·7 per 1000 could be diagnosed as having pulmonary tuberculosis, 8 were doubtful, and 28 had morbid chest conditions not tubercular. The doubtful cases were, where some fine crackles or rales could be detected at the lung margin, or where injected superficial venules suggested deep obstruction from adenitis, and where nasal obstruction generally was present (*Trans. Second Internat. Cong. School Hyg.*, 668).

It may be contended that some of these other lung diseases were tuberculous. Possibly so, says Dr. Rose of Aberdeen children in 1913, but as 700 children were found to suffer from lung trouble, and the Aberdeen mortality from phthisis is only about 30 per annum, the disease, if phthisis, could not have been very virulent.

About this time Grancher, in Paris, thoroughly examined several elementary schools. He diagnosed 15 per cent. of 4226 children

tuberculous, but only three cases as open phthisis needing exclusion from school. His diagnosis was made on the early physical symptom, an abnormal inspiration, fixed and persistent at the same point. This by itself, he says, is a certain sign of tuberculosis (*Munch. Med. Woch.*, 1904, No. 32). It is only necessary, according to Grancher, to auscultate the inspiration and expiration for diagnosis (*Int. Arch. f. S.H.*, i. 131).

If this sign is accepted, probably 15 to 20 per cent. of children will be so classified, and after a time the sign is not detectable. They have recovered.

The later paper of his three co-workers, Mery, Dufestel and Delille, presented the whole subject from the French point of view (*La Med. Scol.*, ii. 2). They used controls and also the ophthalmo reaction, and the sign of D'Espine (*B.M.J.*, 1910, ii. 1136), that is, a whispering sound after the spoken voice, heard over one or more of the upper dorsal vertebræ. It is not infallible, and occasionally is found in a seemingly perfectly healthy child. They classified 24 per cent. as suspect, and 2·25 per cent. as tuberculous.

These results can now be interpreted that phthisis in children is a rarity, almost negligible as a school trouble, but of course where it occurs dangerous to others, and that a large proportion of children shew signs of pulmonary gland infection, which under fair conditions is extremely amenable to treatment by hygiene.

R. W. Philip, who finds 30 per cent. of Edinburgh children shewing stigmata of tuberculosis, presented a view to the Congress on Tuberculosis at Washington in 1908 as to the school part, which, even then, to a school doctor must have appeared without sufficient supporting evidence (*Lancet*, 1908, ii. 1141), although similar views are still occasionally expressed by others of less note.

"In a large number of cases it is to be found in the insanitary conditions of school-life, where insufficient aeration is common; accompanied oftentimes by immediate risk of infection through tuberculosis present in children or teachers, or clinging to the school-room itself."

The writer believes these risks of infection are so trivial as causes of tuberculosis in school they can be treated as non-existent. School as a direct agent in the spread of tuberculosis may be left out of account. Its indirect effects through fatigue, ill-nutrition, want of exercise, and so forth, may result in depressed health and out-of-school infection.

Sources of Infection.—When the sources of infection are explored two main avenues appear, one undoubted, the intestinal, the other more doubtful, the respiratory.

Koch, in 1901, declared the human being not liable to bovine infection, and for the mass of adults this seems correct. The phthisis which forms the great mass of invalidism among workers is of

human origin; although the Royal Commission found bovine bacilli in a butcher dying of phthisis.

In the child before school age, bovine infection, probably through infected milk, is a common cause of tubercle, though not of phthisis. The infection is generally of low grade, and frequently restricts itself to irritated lymphatic glands, or a *locus minor resistantiæ*, a bone or joint which has been jarred or bruised. So, too, the human variety may produce similar lesions. Where the first line is passed, any of the extensions—peritonitis, meningitis, and so on—may rarely happen.

The proportion of bovine to human infection diminishes with age. The main cause of surgical tuberculosis in Scotland is bovine. In Edinburgh Children's Hospital bovine infection occurs in 50 per cent. surgical, and 25 per cent. medical tuberculosis cases. Fraser and Mitchell later stated 75 per cent. of surgical tubercle was due to milk, and one-fifth of the samples of milk shewed tubercle. The Animal Diseases (Tuberculosis) Order of 1925 secures that any cow with tuberculosis or other chronic disease of the udder shall be slaughtered.

The prevalence of bovine tuberculosis in Scotland is two or three times that existing in large English towns. Nathan Raw, in Liverpool, who has been studying the course of tubercle both in domestic animals and children, thinks that practically all surgical tuberculosis is bovine, and bears no relation to pulmonary disease.

Abdominal tuberculosis is double the amount in Edinburgh and Glasgow compared with other European cities (McNeil, *B.M.J.*, 1912. ii). The cause must be that Scottish sanitary ideals for persons or cows are of elementary type. Cattle are animals that lose their immunity if they do not have sunshine and good food. Cattle can be more drastically handled than children, and the building of sanitary byres is cheaper than provision of up-to-date hospitals as a matter of public expenditure. According to Mitchell, 90 per cent. of the infected upper cervical glands shew bovine strains.

In English towns the bovine infection is less. Von Pirquet finds nearly all surgical tuberculosis in Vienna is human, but there milk is said to be always boiled.

Chung Yik Wang gives the percentage in Edinburgh children for non-pulmonary lesions. Under 5 years of age it is 78·4 bovine; between 5 and 16 it is 70·3; and over 16 only 7·8 per cent. He has collated a large number of reports for tables, from which the percentages given in Table 52 of bovine infection are taken (*Edin. Med. Journ.*, 1917). He includes the work of Park and Crumweide in the New York laboratories, who found about one-third of child cases bovine (*Studies, Public Health Lab., N.Y.*, 1910); although in 101 cases of tubercular meningitis in children only 6 were bovine.

The examination in detail of 52 cases of children dying in the Rix Hospital in Christiana, where positive cultures were obtained from mesenteric or lymph glands, shewed 45 human, 3 bovine, and 2 mixed. Two of the three bovine were in the same family, who had drunk much raw milk (*Deut. Med. Woch.*, 1912, No. 10).

Herben and Asserson (*Am. Rev. Tub.*, 1925. 184) found from investigation of 135 cases of tubercular meningitis that they were nearly all of the human type of bacillus, and infection could be traced to persons suffering with active tuberculosis. They state that the whole evidence is predominantly against milk infection.

The tuberculosis of early childhood, then, is not all due to milk infection. At the worst, three-quarters of the cases are due to this in Scotland; only one-third in England, and on an average one-sixth abroad.

Heredity and Family Infections.—Tuberculosis is hereditary in the same sense that cut fingers or scarlatina are hereditary.

Table 52.

Percentages with Bovine Infection.	Edinburgh.	English.	Foreign.
Under 5 years	78·4	31·0	18·1
Age 5–16 years	70·3	21·3	24·5
Over 16 years	7·8	7·4	0·7

The specific resistance of the body cells to various diseases varies normally about a physiological mean, and this variation is hereditary.

The phthinoid chest referred to in the chapter on physique, and often associated with a narrow tubular heart, affords mechanical conditions which facilitate infection by tubercle. There are two types of constitution, mostly affecting blonde, and loosely spoken of by clinical workers as the fine tubercular type, and the coarse type. The fine type, probably an endocrine variation, usually has refined expressive features, delicate skin with the blue veins shewing through, often downy hair on the upper part of the back, and well-formed limbs with small bones. These people are usually of a sensitive mental type, evidenced by excellence in emotional and artistic expression. Many, indeed, are well described in the phrase of former days, "Whom the gods love die young."

The coarse type is the antithesis of this, and verges on the strumous, spoken of later. These types may not be hereditary, but merely congenital or the result of some early acquired and

long-continued slight toxic effects. Here, again, it is the body pattern and not the bacillus that is inherited.

The success of the Grancher scheme (*L'Œuvre Grancher*), which takes children out of tuberculous homes, combats any idea of heredity, as the children later only become tuberculous in the rarest cases.

Priestley, analysing returns from over 42,000 children in Staffordshire in 1918, found no hereditary differences in the two groups as regards height-weight index, nor any special variation in heart, oral, dental, or nasal conditions. Nutritional conditions only varied as his percentages shew.

Table 53.

	Nutriment Excellent.	Nutriment Normal.	Nutriment Bad.
Entire group	3·62	78·33	18·03
Tuberculous	0·35	60·42	39·22

(*British Journal of Child. Diseases*, 1918. 184.)

Familial infection may be severe. Within sight of Edinburgh, in the Queen's Jubilee year, 1887, the writer saw a youth returned from tailoring in the town to his country home to die of laryngeal phthisis. He infected his youngest sister, aged thirteen, who died before him. Twelve months later the oldest sister only remained, and was suffering from empyema; the rest, father, mother, and two or three others, had died as a result of such massive infection. Such a sequence should be now impossible with the Public Health care as developed in Great Britain.

Family infection has been well worked out for New York tenements by Fishberg (*Pediatrics*, 1915. 84). Others had tested several hundred babies under two weeks old without getting a positive reaction to Pirquet's test, although many of their mothers reacted. Fishberg separated out the children according to whether their parents were non-tuberculous, or one tuberculous. They were all Jewish, and not one was seriously sick. They were the children of families applying for relief.

Table 54 gives percentages reacting to cutaneous tests.

In an analysis of records of 18,000 children of tuberculous parents in Stuttgart, Weinberg found that the mortality was greater the nearer the death of the parent. Putting normal as 100, the mortality was 267 and 333 for five years before or five years after death of the parent, but only 121 and 227 for more than five years. Similar figures, 133 and 156, and also 114 and 82, appear for all other diseases (*B.M.J.*, 1913. ii. 1095).

Langendorfer, who investigated the fate of 269 children in fifty families at Bonn, found that, where a parent was tuberculous, half the children were also tuberculous. The mother was a more dangerous factor than the father, and later-born children more endangered than others. The most dangerous times were before five years old and about puberty (*Zeit. f. Tuber.*, Berlin, 1920. 150).

The Galton Laboratory Memoir (1914), by Pearson, Williams, and Bell, concludes from statistical investigation that puerile phthisis is due to an infection to which probably those whose parents have suffered from adult phthisis are more liable. These results are based on Mrs. Williams's data, and she assigns 41·1 per cent. boys, and 35·6 girls of the twelve to thirteen-year-old group to the classification "phthisis" and "doubtful phthisis," values which most school doctors would refuse to accept.

With these familial relations as they are, there seems little

TABLE 54.

PERCENTAGES IN EACH AGE GROUP GIVING POSITIVE REACTION.

	Under 1 Year.	1–2.	3–4.	5–6.	7–10.	11–14.	Over 14.
608 children, non-tuberculous parents	10	33	43	50	65	69	75
729 children with tuberculous parents	15	55	69	66	71	75	84

need to invoke continued and latent child tuberculosis as an origin of adult phthisis.

The main portals of infection have already been specified as digestive, or respiratory. In bovine infections of children the medium seems infected milk. For children under five milk should therefore be sterilized, over this age the advantage of the vitamin and calcium content is so great, and risk of infection so small, that for the ordinary school child or adult the writer would only sterilize milk as a means of preservation. Many young children are infected with human tuberculosis. The infection is then probably due to expectoration from a case of phthisis; and the infection should be assumed, and the adult traced, unless other source is probable.

During the War some American cities made rigorous rules against food-handling by consumptives, in the hope of protecting children.

In Swansea, Dr. Clifford (the Tuberculosis Officer) had observations of sputa as found in streets, squares, parks, and football grounds, and found that nearly 60 per cent. contained tubercle bacilli (*B.M.J.*, 1914. ii).

Dust is supposed to be a great diffuser of tubercle. The dust of the public-house, so many of whose frequenters and occupiers generally succumb to phthisis, dust from the floor in finger-nails of young children, these are regarded as sources of tubercle. Dust, however, acts as an irritant. Dr. Barwise thought he could map out the siliceous regions of Derbyshire by phthisis mortality. Dust may very rarely convey tubercle. Not once in a hundred attempts is tubercle likely to be recovered from dust of rooms where it might be expected.

In Chicago, where the drive against tubercle has been thorough, a dust investigation was made by the Sanitarium staff. Sweepings were used of 128 rooms of the Institution, and of cottages inhabited by phthisical cases, who, however, were trained to cleanliness. Inoculations of the dust in 256 guinea-pigs, killed on the sixtieth day, shewed only two with suspicious tuberculous lesions (*City of Chicago Municipal Sanitarium Bulletin*, May 1918).

Dust investigations at the Trudeau Sanitarium were taken from rooms with patients with many bacilli and much coughing, and inoculated in 24 guinea-pigs. They were all free from tubercle when examined after 41 days. Spoons, forks, and cups were found infected after breakfast, but no knives or plates. The saliva of patients always infected guinea-pigs, and kissing plates left infection. Our own Post Office investigations shewed that even telephones habitually used by tuberculous patients were not infective.

The Mechanism of Infection.—Many years ago, the writer handling large numbers of tuberculous patients made the general deduction that the nearer the lips the graver the outlook. The infective material somewhere in the intestinal tract passes to the lymphatic system, or possibly blood stream. The tonsils may offer entry, or it may be in the intestinal region. The mesenteric glands offer resistance, a few bacilli escape through, and are arrested in the lung, setting up a focus often found as a caseous mass low in the lung. From this the bronchial and tracheal glands are infected and enlarge and caseate and may spread infection further.

It seems doubtful whether inhalation infection of the lung plays any considerable part clinically, although this is commonly assumed to be the route. The diffusion must sometimes be through the circulation, when scanty bacilli chance to find a locality with lowered resistance.

Actual experiments shew that tubercle bacilli introduced into the stomach of guinea-pigs infect the lungs.

Flügge regarded droplet infection as the most dangerous, and in this way could infect guinea-pigs with as few as 50 bacilli, whilst it took millions through the intestinal tract. He considered dust infection as unimportant. The dry sputum does not form dust capable of flying about. The observations at the Trudeau Sani-

tarium confirm this view. Where flies carried tubercle from sputum, and apparently suffering from diarrhœa, flecked chopped-up carrots with white material containing tubercle, this white material caused infection if injected, and the animals died with tuberculosis, but other guinea-pigs could eat the material so flecked and were not infected (*J.A.M.A.*, 1919. ii. 1576).

We may therefore neglect dust or tubercle "clinging to the school-room itself" (Philip), and take it that the chief source is swallowed from infected materials, or sprayed from sufferers, and that apart from the neighbourhood of an open case, the risk of sufficiently massive infection by inhalation is small.

Dust infection may be neglected in school. The child to child infection must be very rare. Possibility of infection by a tuberculous teacher should not exist. So far as actual tubercular infection of the children is concerned, 99·9 per cent. is probably out-of-school infection.

But, with the possibilities of out-of-school infection, school conditions may yet powerfully contribute to this event by reducing immunity positively, through fatigue from overwork, or through heat accumulation from overcrowding; negatively from want of exercise, want of food, want of rest, and want of space. These factors are considered on other pages.

Scrofulous Types.—One variety rarely seen in school work, formerly common, is the strumous or scrofulous type. The term strumous, perhaps, connoted the cases which did not go beyond enlarged suppurating cervical glands, and was a slighter form than the second; scrofulous where the whole body seemed more or less affected. The coarse tubercular individual being the fundamental, of which these were developments.

Thirty years ago they were common in hospital practice, and presented a distinct habit or diathesis which nowadays suggests that some vitamin want, or endocrine influence, was then at work, but has become less effective.

There were also other possibilities of uncleanliness and chronic poisoning. The death-rate of tuberculosis within memory was double what it is to-day.

McNeil regards scrofula as status lymphaticus with tubercular infection, adducing the severe reaction which these cases shew with tuberculin (*Brit. Journ. of Child. Diseases*, 1923. 197).

A slight infection, which in a normal individual would result in a mild attack, here causes disease.

Scrofula is a syndrome restricted to the growing period. There may be a want of destruction of the so-called embryonic ferments. The nutritive vitality of the cells seems depressed. There is almost a lymphatic stasis in the tissues. Thickening and congestion of the dermal structures result in a characteristic facies. The skin

and mucous membranes present localized areas of inflammatory or catarrhal change due to depressed immunity and infection by various skin cocci of low virulence.

Their toxins cause, among other effects, scrofulo-dermatoses, eczema, impetigo, lichen, also phlyctenulæ, rhinitis, conjunctivitis, blepharitis, often otitis, and recurrences of bronchitis. The ever-present tubercle bacillus finds congenial soil, and some nidus in bone, joint or skin results in tuberculous ulceration, indolent and often multiple, and when healing liable to break down again.

There may be rarely a superficial scrofulous ulceration from streptococci or other forms without tubercle being evident.

In any case, the toxins from these lesions appear to maintain or even aggravate the constitutional condition. A scarcely infective bovine virus suggests itself, and the scale is turned against it by the improved metabolism from good feeding, the vitamins of cod-liver oil, the stimulation of the fresh air, and, above all, the vitalizing effects of sunshine on the skin. For although tardy, treatment of these cases generally results in recovery, and in past times the " Royal Touch " was a sovereign remedy to multitudes.

The signs and symptoms of tubercle in children are many, and a latent tubercle has to be recognized. The bovine bacillus expends itself in pre-school ages. It is a great factor in the crippling diseases which originate in the first five years of life. Other evidences, formerly ascribed by the writer to infantile neurasthenia, are probably the debased nutritional results of toxins from chronic tubercular infection of slight degree in mesenteric glands.

Schmidt Monnard drew attention to the loss of weight and depression of the health of the children in their first six months at school in Halle. These were mainly children of the industrial class, and tubercle is quite common among them.

The story of such a case, got from the mother, is that the child was quite healthy, perhaps chubby and rosy-cheeked, till he went to school at the age of five. Then he soon falls off in health. He lies about at home, does not play so freely as before, becomes pale, gets thin and peevish, does not sleep well, but sleeps so heavily in the morning that he can scarcely be wakened. He does not want any breakfast, may even go to school without it ; or, if he has had it, may be sick and vomit, either before going to school or during the early forenoon. The child gradually takes on a thin, nervous appearance, might easily be termed " the nervous child," with dark, translucent skin around the eyes. There is an appearance of want of interest or ambition, almost the indifference of the chronic invalid, unhealthy fatigue, perhaps a few days' absence, then returning to school, going on in poor health for a time, and then, though still stunted and unwholesome looking, he slowly recovers.

The school doctor more often sees a girl, 10 or 11 years of age,

when the anorexia or even morning nausea may be prominent, and the child has almost a cachectic appearance. As, however, there is no very distinctive illness, the general occurrence of these cases is not known.

The medical officer of health has usually but scanty acquaintance with the inner life of the school, and the school doctor has a routine to follow which almost precludes knowledge of this kind of child. The writer saw many in Bradford, and followed several of the first-described type through infancy to their early school-days with the result as described. They are difficult to discriminate from the nervous, erethic type sometimes called unstable. The family doctor, however, and occasionally a head teacher, has knowledge of these cases. The child may be passing through an attack of tuberculosis, non-progressive and otherwise latent. C. J. Thomas, in a special detailed examination of children in 1913, attributed marked ill-nutrition to tubercle in 25 per cent. of the cases.

Lassitude, anorexia, anæmia and quickened pulse, with possible irregular temperature and occasional night sweats, make up a suspicious picture of toxic infection probably tubercular, more rarely streptococcic or rheumatic.

The main concentration in diagnosis has been on chest tuberculosis, apart from pulmonary tuberculosis or phthisis, but to invoke a special tuberculosis department here is extravagant, and confusing to the public.

Probably no case of phthisis exists as a result of drinking milk, and the rare cases of ordinary phthisis in a child are generally associated with an open case in an adult. It is often diagnosed where it never existed, and for this reason many notifications must be suspect.

The chest trouble which is a cause of difficulty to the school doctor is what Grancher called "La tuberculose ganglio-pulmonaire." The infection of the lymphatic glands about the root of the lungs, the tracheal and thoracic lymphatic glands which become infected by bacilli settling in them, arrested in passage from the lungs, these may come either as a secondary deposit, the result of bacilli which have escaped the mesenteric portals, or from some which have been inhaled. From the root glands through the blocking of the lymphatics the lungs may again become infected, but in most cases the powers of the individual soon bring the attack to an end, or if not rapid tuberculosis is likely.

Diagnosis of changes in young children due to infection of the glands has reached great refinement, but alone is not sufficient to decide whether active or quiescent.

When a healthy-minded and normal child quickly changes to an easily tired, inattentive child without appetite, and possibly

having night sweats, active tubercular disease must be sought by careful examination.

There are cases where physiologically breathing seems altered in a thin child, or bronchitis clearing up may present a long continuing distribution about the roots of the lung. Bronchitis is commoner in children than adults. With nasal obstruction, or rhinitis, there is often some collapse along the front edge of the lungs, especially in those with marked adenoids. Mumford suggests that nasal obstruction may be reflected by impaired action in the corresponding lung, and certainly nasopharyngeal obstruction should considerably discount any chest findings on the first examination.

Von Richter (*Deutsch. Med. Woch.*, 1909, No. 20) pointed out how frequently catarrhal signs at the right apex, defective breathing and collapse were present with any nasal obstruction, and suggested that a sanatorium may actually be a dangerous milieu for such patients.

Lees values percussion with the patient lying relaxed (*B.M.J.*, 1914. ii. 461), and also for the back when sitting forwards. He finds before auscultation gives any indication of existing tuberculosis, definite dull areas towards the top of each lobe, and twice as often on the right side.

Clive Riviere, who has in addition had great school experience, values gentle percussion, the dullness of tracheo-bronchial glands shewing generally as a vertical one-sided patch higher up.

The condition of cervical and other lymphatic glands has been cited as a contributory element of diagnosis, especially small enlarged glands above the clavicles, but these are common in school children, and Mumford noticed that cases of tuberculosis usually do well where there is a general but slight reaction of all lymphatic glands.

Another aid is chest examination by the Röntgen rays. Except in advanced cases, this requires considerable experience. The screen examination may shew limitation of movements, especially of the diaphragm on one side, and possibly some increased opacity of the lung on the same side. The small centrally placed tubular heart is also supposed to suggest a favourable soil for infection.

For the lung condition a photographic plate to shew fine detail is necessary. Striations supposed to represent lymphatics, shadows in patches, and streaks and a general mottling about the roots of the lungs are noticeable. These may occur in healthy children, although my former colleague, Dr. A. G. L. Reade (*Lancet*, November 30, 1912) could find none in the boys of the training ship *Exmouth*.

The opacities are made up of small rounded opacities in groups, and sometimes one of the striations terminates in a little oval spot

or patch. These have been taken to represent tubercular foci, but their presence or absence is only presumptive evidence.

The National Tuberculosis Association of America examined 500 school children who reacted negatively to tuberculin, and decided that it was impossible to define a normal child's chest owing to wide variations. Calcified nodes at the root of the lung are common in the normal chest, and all evidences must be collated for a judgment.

In some ways latent tuberculosis may be regarded as a focal infection. If other centres of sepsis can be excluded, it is still a possibility which is increased if there is considerable alteration of blood pressure between the supine and the erect posture (Sewall, *Am. Rev. of Tub.*, January 1920).

Krantz, at Hendaye, studied the temperature as a means of early diagnosis (*La Med. Scol.*, 1909. 123), and thought increase significant. The temperature of school children, however, is so often over 99° F. that the writer attaches little importance to it.

Krantz regards the following as of value for diagnosis: "A temperature up in the afternoon, remitting in the morning, and in some cases even normal then. Temperature which has abrupt and irregular rises without sufficient cause. Persisting fever which falls when the child is put to rest. Irregularities after walking, which the same effort shews sometimes weak, sometimes strong."

The tendency to raised temperature is commoner in poor children. Up to adolescence there is also often a facies which hints at latent tuberculosis, a persistent air of exhaustion or fatigue, with temporary alertness, a meagre and ill-nourished appearance with pallor about the orbits, and yet an earthy-yellowish complexion difficult to describe. Where a child seems wanting in tone and without other signs than these, it is well to suspend the diagnosis for a time, meanwhile suspecting and treating as tuberculous. When the latent type passes over into the actively progressive form in the chest glands the picture is different according to age.

Clive Riviere describes how in children during the first dentition there are acute and often intermittent symptoms, asthmatic attacks, expiratory dyspnœa, and characteristic ringing or spasmodic cough, with possibly signs of pressure. These cases are seldom seen by the school doctor, divorced as he is from clinical medicine.

At the second dentition symptoms are few and slight, simply chronic wasting disease, and possibly signs of prolonged pressure from diseased glands. After adolescence tubercle becomes increasingly prevalent in the adult form of phthisis. Candidates for scholarships, or for the teaching profession, have sometimes to be rejected on account of their poorly developed chests. Some of them, long lanky individuals acknowledge that they never have played games, or taken active exercises.

Industrial fatigue is a factor in etiology of phthisis which accounts partly for difference of mortality between the sexes being in proportion to industry, and therefore most marked in males. This difference is reversed during the school ages.

The author first drew attention to this (*Journ. Roy. Stat. Society*, 1897. 625), shewing that at all ages the mortality from phthisis is decreasing, yet in the five years before and five years after school ages the relative mortality rate among females was decreasing, whilst at school ages this mortality is reversed and goes down faster among the boys than among the girls.

Returning to the subject twenty years later (*School Hyg.*, 1917. 37) he found the disparity increasing.

In the last decennium the process appears to be arrested from 1906, but the fluctuations are very irregular, and war conditions

TABLE 55.

PHTHISIS DEATH-RATES OF FEMALES WHEN MALES CORRESPONDING = 100.

England and Wales.	0–	5–	10–	15–	20–
1851–60	96	*118*	*170*	146	—
1861–70	96	*110*	*172*	142	100
1871–80	96	*110*	*176*	143	100
1881–90	94	*129*	*204*	140	100
1891–1900	87	*139*	*210*	129	84
1900–1910	85	*139*	*233*	131	80
1911–1920	87	*132*	*218*	131	82

which seriously increased mortality in adult females may have affected the change in school ages.

The explanation may be the freer life of boys, meaning sounder immunity, the want of exercise affecting the girls in this respect. The former restricted life of the girls being steadily replaced by school-life may result in greater exposure to outside infections. The earlier maturity of girls, too, involves an earlier liability to lethal infection in the second half of school life.

Lastly, the increase of physical exercises and games among girls has possibly stayed the relative increase of mortality among them. Whatever the cause, this result has, since the author's observations, being noted abroad.

Kirchner (*Zeit. f. S.*, 1912, Append.), Steinhaus (*Zeit. f. S.*, 1910. 275), and, earlier, Virchow (*Zeit. f. S.*, 1907. 41), also by Ito as regards the prevalence among school-girls in Japan.

Notification.—The Public Health (Tuberculosis) Regulations of 1912 introduced the requirement for a school medical inspector to

notify weekly all cases of tuberculosis which come to his notice in the course of inspections held at public elementary schools. It is immaterial whether a case has been previously notified by some other medical practitioner, but the school medical inspector is not required to notify any case he has previously notified.

The Clause which enacted this runs : "*Article VI.*—Every school medical inspector shall as soon as practicable after the end of each week make and sign a notification in Form B of all cases of tuberculosis of which he has become aware in the course of inspections made by him during the week, of children attending public elementary schools, and shall transmit the notification to the medical officer of health for the district within which the places of residence of the children are situate. When the places of residence are situate in more than one district, a separate notification shall be transmitted to the medical officer of health of each district."

Form B requires name of child in full, age, school, place of residence in full, and localization of disease.

Notifications, which must be very unreliable as regards phthisis below puberty, do not shew such disparity as mortality. They are also falling rapidly, as 6300 at the foregoing ages in London in 1913 became reduced to 3200 by 1923. In that period school doctors notified 1111 boys and 1191 girls with phthisis. The chest cases noted for treatment are below 1 per thousand children examined, and have diminished to one-eighth in the decennium.

This rapid fall in the prevalence of tubercle must be due to better hygiene. The suggestion of some biometricians that the germ plasm is being improved through elimination of the unfit may be true over long periods of time, and even then it is noteworthy that the phthisical are prolific.

American writers have pointed out that the Irish in the great cities there die off at twice the rate they do in their own country.

The increase of tubercular mortality in the war-raided Eastern areas of Central Europe was remarkable, reaching ten or a dozen times its pre-war rate in such places (Dublin, *Nineteenth Annual Meeting, Am. Nat. Tub. Ass.*, 1923. 317). Post-war Germany is still riddled with tuberculosis (1925).

In the matter of diagnosis personal equation may play a preponderant part. Taking three adjacent county areas, the results for 1912 were published for pulmonary tuberculosis as : 5·4 per cent. of 2316 boys, 5·9 per cent. of 2287 girls in half of Worcestershire ; 0·4 per cent. of 2536 boys, 0·6 per cent. of 2525 girls in the other half ; 0·12 per cent. of 9314 boys, 0·12 per cent. of 8985 girls in Staffordshire.

Evidently a large part of the fall in the notifications may be due to increased experience on the part of the examiners, though, as

the number of deaths is also decreasing, it cannot be the whole explanation.

In the Report of the School Medical Officer for Sheffield, 1921, a list of 70 schools is given, the exclusions on the recommendation of tuberculosis officers varying from 0·49 per 1000 to 18·52. As 11 of these schools are over 10 per 1000 and 10 of them below 3 per 1000, either the personal equation is great, or, more probably, Sheffield permits locally a ghastly amount of disease which judicious expenditure could avoid. And yet Dr. Kaye's figures (*The Medical Officer*, 1921. 21) shew that the West Riding generally is an example for England.

The writer saw much of phthisis as an industrial result during ten years at Bradford Royal Infirmary, but it was the study of affected children in school, and the experience of the open-air schools, which first led to the realization of a stratum among debilitated children suspected, but never before definitely ascertained, until they were brought together in the tuberculosis school at Kensal House.

The *Report of the Medical Officer* (*Education*), 1911, page 111, points out how "The battle with tubercle has to be gone through by everyone in the first few years of life. In a community like London the maintenance of a high average of the public health actually depends on the maintenance of some infection by the causes of disease. Those affected need never suffer *malaise*, but they acquire and maintain the amount of immunity required to prevent epidemics and catastrophal outbreaks. Tubercle as an infection is probably more ubiquitous than measles, and, although everyone acquires it, yet few become diseased. Not more than three children in a thousand in school present evident phthisis. Yet searching the families of adults suffering from tubercle, children are found coming from such an environment who are themselves infected, and the observations taken in school have shewn that the majority are seriously affected. Only long observation can determine how extensive this infection is, and whether the main factors contributing to serious or lethal disease are heredity, debilitated physique, or infection."

For the ten years 1900–1909 the amount of schooling over 5 years of age given to tubercular cases came to 68,880 years, and taking the cost as £4 15s. per head this represented £327,185 actually spent in London in educating children who died of tubercle before they reached the age of 20 years. The estimate does not make any allowance for the cost of illness, or for those who survive crippled or in chronic ill-health.

If the deaths are so numerous, it may be assumed that the ill-health without death is also extremely costly to the community. The writer estimates the cost of tuberculosis of school children in

that period in London as at least a million pounds, without any return.

These children are from homes where generally an adult is infected. The child, even if normally able to resist infection, is still almost continually exposed to it, and frequently in more massive doses than is usual.

Adult men, from fatigue, and possibly also from the irritation of dust encountered in their work, are the most liable to infection. When the breadwinner is affected, as is so commonly the case, the invariable rule is a slow sinking of the family into poverty. The children, already possibly of weak immunity by inheritance, from want of food, and the surroundings and pressure of this poverty, want of sleep, of play, of clothes, of cleanliness, are reduced to conditions of health which make infection almost a certainty.

If tubercle is an infection pure and simple, predisposed to by the debility of overwork and the want of vitality due to bad housing, poor wages, and caused by infection from other persons in the community, it is the duty of the community to come to the aid of the sufferers, whether actually diseased, or in danger of disease, and relieve them fully and freely without the assessments and charges which at present stand in the way. Assessments may be made, but there is no legal duty to pay. They are often extorted under threats, and then recorded as voluntary payments. Even if the tendency to tubercle be largely inherited, that inheritance in the case of the breadwinner or child is aggravated by the conditions of life imposed by low wages and scanty living room.

It is in the public interest to do all that is possible to relieve the tubercular child and to aid its natural tendencies to recovery. The chief aid that can be given is nutritional by the supply of plenty of good food, and the stimulation of metabolism by fresh air. Mid-day dinners can hardly be said to be sufficient. Whatever interferes in any way with this food supply is a direct obstacle to the child's chances of a healthy life. In addition, freedom must be procured from continual infection, and from the care and worry which even affects the children of a sinking home.

For these children so definitely affected that they wear a blue badge in school, the tuberculosis school is only better than nothing, for the others it is insufficient for their needs. They should be removed from the town altogether and from their homes, and live with plenty of space in residential convalescent schools or homes of recovery.

Hitherto the school authority has not been able to do much against tuberculosis. Indeed, the public health authorities have been very lax in regard to this disease, which is the chief single cause of disablement in adult life in this country.

A great deal has been talked about the importance of tuberculous milk, and this has been enormously exaggerated as a factor in dissemination of disease, whilst the other contributory factors have been much neglected. Calmette, indeed, hopes to succeed with a cultured living bovine vaccine in protecting without infecting (1925).

The tubercular cow has unfortunately attracted attention, compared with the tubercular person. As a cause of disease after the first years of life it must be of less and less importance. Heredity from the past is almost unalterable in the present, but the other conditions of debility, notably the depressing factors, want of food, chronic fatigue, alcohol, and the irritating factor of dust and infection, are all more or less within immediate control if the price of control is paid.

The tuberculosis tax must be paid in money or lives. It meant over a hundred funerals a week in London in 1923. The lowest record of 5285 deaths from tuberculosis was then reached.

The London deaths from phthisis at school ages in the year of the above Report were 137, and thirteen years later are 101, a reduction of 26·5 per cent. To-day no tuberculous child is left wholly uncared for or untreated. The official, however, who has the grit to offend vested interests by looking at a social topic from the scientific aspect, whilst honest, may be lacking in worldly wisdom, and later has to pay the price.

The Treatment of Tuberculous Children.—There are two groups which might be called surgical and medical. Treatment may also be separated into the general prophylactic treatment of the pre-tubercular conditions to build up immunity, and secure that the child is preserved from constant and massive dosage with infective material, and the treatment which is remedial.

The special treatment in regard to the school varies with the two classes of cases. There is no use wasting a child's energies in education whilst it is suffering from active tuberculosis. Education must take a subsidiary place until treatment has placed the child's advantage over the bacillus beyond doubt.

The treatment has to be thorough. Formerly, cases of bone and joint disease were treated by palliative relief of symptoms. The hospitals could no longer afford beds for them. "Children should be taken there and kept till healthy, not merely relieved from the most urgent symptoms and sent out again to drag away months till urgent symptoms again supervene, as is the common history of such cases at present" (*L.C.C. M.O. Ed.*, 1906. 144). The same series of Reports (1910, p. 169) proposed methods of treatment needed in residential schools to which we are now gradually attaining. Fifteen years later the L.C.C. are proposing to remove children from heavily infected homes.

Writing in 1911, Dr. Walsh, the Medical Officer of Merthyr Tydfil, finds the net result is that treatment is negligible and useless. If tubercular children are to be saved, and pre-tubercular prevented from infection, provision must be made for systematic treatment. The responsibility for it should be taken out of the hands of the parents, who, in most cases, have proved themselves unequal to the task.

Tubercle in all forms is amenable to prophylaxis, and in the bovine forms to treatment, but it may need to be long continued.

These surgical cases are mostly advanced to abscess formation and crippling deformity. They should be caught earlier than the elementary school. The majority would have been prevented had there been nursery schools. The stitch in time expenditure on nursery schools is true economy. The nursery school must now be recognized as an indispensable part of the social mechanism. Nine-tenths of the crippling from tuberculous disease would not occur if children were under survey—if only by a school nurse—between the ages of 2 to 5 years.

The medical cases are mainly chest cases. Meningitis is only mentioned as a rarity in the experience of the school doctor, but it is a terminal infection in any class of tubercular children, and the rare but ever-present possibility of encountering its early onset must not be overlooked.

Children are probably under more thorough observation than adults. Contact children should be examined at intervals of two or three months.

Cases of tubercle detected by local practitioners, school doctors, hospital and institution doctors, or at the tuberculosis dispensary, are notified to the medical officer of health of the district where the child resides. If necessary, the child is referred to the dispensary. At the dispensary the disposal for treatment is arranged. It may be open-air school, tuberculosis school, or sanatorium school.

No child who has definite tubercle should be returned to the elementary school under a couple of years.

It would be cheaper and preferable that all this work for children should be done in connection with school than at a tuberculous dispensary, which unnecessarily duplicates work.

The fitness of a child for special school education, whether exclusion or admission, is solely on the decision of the school medical officer. Unfortunately, it too often depends on evident disease. " Say, doctor ! how ill must a fellow be to get into this school ? " is the legend under the frontispiece of an American publication regarding open-air schools.

The practice at Kensal House, where only comparatively advanced " suffering " cases were admitted, according to the decision of the Medical Officer of the Board of Education, illustrates the

aphorism that "preventative sanitary measures usually are taken after the need has arisen!"

The classification is made largely on temperatures.

Grade I.—Normal or sub-normal morning and afternoon temperatures. The full school work, exercises, games and gardening allowed. A white badge worn.

Grade II.—Temperature rising to 99° F. or more in the afternoon. The ordinary school work, but no running about or games. A red badge is worn.

Grade III.—Temperature rising to 99° F. or more in the morning and 100° F. in the afternoon. Blue badge.

Children with 101° F. sent home to bed and visited by the dispensary doctor.

The charts are gone over every Monday and the grading made on the previous weekly record.

The Queen's Road Open-air School at Barnsley takes only tuberculous children, and in the 1913 Report gave 35 per cent. cured, "and by 'cured' (writes Dr. Sadler) I mean disappearance of rales, pectoriloquy, tubular breathing, and impaired percussion, but not necessarily an equality of vocal resonance between the two apices." Here arithmetic was taken out of the time-table, and the time for reading, composition, history, and singing reduced by six hours a week. Most of this time saved being given to gardening and housework for both boys and girls.

To this relaxation of mental and desk work, not only for the tuberculous, but for all children below eleven in the primary school, the author attaches the greatest importance, believing that children would learn more if the time for it was much reduced. The social duties and outlook of citizens requires developing, the child should learn as a sacred duty in all public questions to think of its own personal interests last. The school should carry this forward in such measure that the school itself will become a social centre for later life. In this way it will act as a powerful prophylactic, not only in making honest citizens, but in adding an interest to life, and helping the elimination of fatigue, exhaustion, and their corollary drink, it would also reduce the phthisis incidence and death-rate.

The treatment of external tuberculosis by the improved metabolism resulting from sunlight as well as fresh air was empirically followed out to a brilliant success by Rollier of Leysin. However severe a case, it is treated by gradual exposure of greater and greater areas of skin to direct sunlight over daily increased periods. The eyes are protected by smoked glasses, and the head with a white helmet. At first only the feet are exposed for five minutes at hourly intervals, then the legs, and so gradually more, alternately back and front. The skin should get intensely pigmented. Cases are now being treated in open-air schools on these methods with excellent results, and at Chailey Heritage Schools a special ward is

set apart for this heliotherapy. The Treloar children, under Sir H. Gauvain, have demonstrated what can be done in this country, and many of our open-air schools have taken advantage of the knowledge.

The treatment must be used intelligently. Feverishness should not be produced. Pigmentation of the skin is practically proportional to the good therapeutic effect. Those who do not pigment may be harmed. There are, too, certain substances which may even sensitize a child so that it reacts badly to light.

An indirect effect rendering likely a reduction of tuberculosis among young adults in the next generation is the enormous improvement taking place from dental care. The improvement in the condition of teeth among adolescents in London now is remarkable. Case after case presenting themselves with perfect dentition. The septic and gastric results, the sequelæ of oral neglect, set up ill-nutrition and loss of immunity among industrial workers, and till recently was exceedingly common as a precursor of phthisis. There now seems no reason why every child should not have this prophylactic cure.

Haven Emerson, after personal experience (*Am. Rev. Tub.*, 1924. 191), whilst admitting the scarcity of food, concludes that Germany is now presenting a picture of acute spread of tuberculosis, due primarily to intimate, continuous, and massive infection made almost inevitable by the conditions of housing and the breakdown of many of the facilities and resources for segregation of tuberculosis patients from other members of the family. Dr. King Brown reports that of 461 persons notified as suffering from tuberculosis in Bermondsey in 1924 only 4·3 per cent. slept alone in a room.

As the amenities of life improve, so the powers of immunity turn the scale against the ever-present bacillus.

The whole matter is essentially one for education. The community must learn that the death-rate from tubercle can be reduced indefinitely if the price is paid.

One thing is clear. Any assessment for payments on account of treatment should not be permitted. They are not legal. An Authority which permits pressure to extract voluntary payments is evading its duty by this camouflage. The tuberculous child has a balance against the community which common justice should compel every effort to repay.

Free trade and cheap prices for all the necessities of healthy life, housing with sufficient space for breathing, exercise, the diminution of chronic industrial fatigue, and the resulting drink bills, the provision of plenty of free play for the children, and recreation and freedom of access to the land. The mountains and seashore for the children, and their elders, are the kind of requisites which must be attained for everyone if tubercle is to be made a negligible item in regard to Public Health.

CHAPTER XVII

RHEUMATISM AND HEART

Blood Circulation.—The superficiality of work done in schools is nowhere more completely demonstrated than in connection with conditions of the blood, anæmia, pulse rates, and blood pressure, and yet there is here an immense, almost unworked field, not only for diagnosis and prognosis, but also as a means of measuring or checking methods of schooling or educational treatment.

The hygienic value of Montessori and Dalton methods and their rivals could thus be measured, and effects of multiple examinations and school fatigue duly assessed. In England, with school inspection more general than anywhere else, scarcely anything has been done beyond hæmoglobin estimations by Tallquist's scale, and a few blood pressure determinations.

Pulse rate in children diminishes with age, but as it is liable to such ranges of variation from comparatively slight causes, little attention has been paid to it. With scholarship children or candidates for bursaries, a pulse rate of 100 is worth noting. Anyone with a pulse habitually over 100 wishing to enter the teaching profession should be rejected, as experience shews that they are either too nervous to stand training, or prone to develop hyperthyroidism, most undesirable, especially for anyone taking up teaching.

The value of pulse rates increases enormously if blood pressures are also known. Probably a formula will one day be devised relating the normal blood pressure to volume of the body. At present blood pressure is known to increase with age, with height, and with weight, and to be higher in nervous, jerky types of children than others.

Scholarship boys in London, aged 11 years last birthday, have blood pressure varying from 100 to 115 mm. of mercury. For younger school children it varies from 80 to 100 mm.

Dr. A. G. Wilkins reports in 1923, measurements of 300 Staffordshire school children aged 8–13 years. The average blood pressure varies with weights from 40 to 100 lb. by an amount from 99 to 117 mm., and with heights from 40 to 64 in. by 96 to 114 mm.

V. Salle (*Jahr. f. Kinderheil.*, 1911) finds lowered pressures in lymphatism.

Thomas (*Schw. Med. Woch.*, 1925, ii, 896) with 674 children,

boys aged 7–11, syst. 98, diast. 61 ; aged 11–14, syst. 107, diast. 67. For girls aged 7–11, syst. 93, diast. 58 ; aged 11–14, syst. 106, diast. 63. The amplitude of pulse movement is 5–10 mm. greater than in adults.

Hamburger (*M.M.W.*, January 31, 1911) noticed increased pressure in nervous children, and also arterial rigidity which he put down to school troubles (Schulsorgen). The best and sharpest children being more especially affected.

Kaup (*Monats. f. Kinderheil.*, 1910), and in London, Glover, have noticed the tendency to increased blood pressure with nervousness, and Stocks and Karn found it averaged higher in schools with strict discipline.

Comparing well-fed children of the School of Education in Chicago weight for weight against poor children of the Jewish Institute, it was surprising to find highest pressure among the poor children (Young, *Buffalo Congress Rep.*, ii. 24).

A considerable rise at early puberty, which is not maintained, is described by Friberger of Upsala (*Arch. f. Kinderheil.*, 60 and 61) and McCurdy has examined this thoroughly, finding the lowest systolic values in pre-pubescent and post-pubescent boys, with a jump up between (*Am. Phys. Ed. Rev.*, June 1910).

Leipoldt of Cape Town, after fifteen years' work in London and South Africa, under very varied conditions, finds that blood pressure observations give no useful indications in school children (*B.M.J.*, 1926. i. 347).

Stocks and Karn, *Blood Pressure in Early Life* (Camb. Univ., 1924), have used a standardized method. Subject in sitting posture has pressure taken, a 12 cm. sphygmomanometer band is applied above left elbow, the arm being rested on a table with palm upwards. The end of a stethoscope was applied to bend of elbow by elastic band. Readings were taken as pressure was released. The systolic at first and diastolic at fourth point of change. Pressure increases slowly till about eleven, when the gradient becomes accelerated during adolescence to reach adult values at eighteen. Diastolic pressure follows more slowly. The pulse pressure rises rapidly during adolescence, then sinks slowly to original value about twenty. This indicates that the unit weight of cardiac muscle is doing more work about adolescence than either before or after that period.

However measured, the effect of posture which should be sitting, and temperature, which should be the normal room temperature of 62° F., must be attended to ; cold raising the pressure and heat and moisture depressing it.

Higher readings also temporarily follow ingestion of food or much fluid, or exercise, or psychical excitement, so that a uniform time of day should be followed. Even then the same child may give very varied readings if tested from day to day.

Dr. R. A. Askins found an average B.P. of 103·5 mm. in boys of 14–15, and noted that abnormally low pressure was always associated with subnormal weight and nutrition.

An idea that heredity plays a considerable part was investigated by Alvarez, who measured over 8000 Californian University students, and concluded that regular measurements above 127 mm. in women and 130 mm. in men indicated a diathesis which tends to cardio-vascular disease (*J.A.M.A.*, 1920, ii. 1371).

After a strenuous effort pressure rises, continues up for a time, then sinks. The pulse rate is also affected.

Anæmia.—The hæmoglobin content of the blood in scholars is almost always estimated by Tallquist's method, in which a drop of blood taken up on white blotting-paper is immediately slipped under an opening in a tinted paper and brought in contrast with different tints till it is matched. The match tint giving a colour proportioned to hæmoglobin percentage.

De Vendictis found this method when tested by Fleischl's apparatus to be accurate and of negligible error (*Brit. J. Child. Dis.*, August 1907), but other observers have noted its roughness, and the writer regards it as an indicator rather than measure of anæmia.

Most school measurements have been in regard to open-air schools. Unfortunately, there are no systematic and continued observations on the hæmoglobin content, as the seasonal variation in the index would almost certainly be found high enough to considerably discount all published figures.

An instance may be taken in some children observed by Dr. Häberlin at Wyk on the Baltic Coast. They are quoted, as his work was done very accurately, using Gower's hæmoglobinometer.

Some 28 Berlin children received there averaged 79 per cent. hæmoglobin in June ; they left in August averaging 92 hæmoglobin. From beginning of September to December their hæmoglobin fell from 92 to 86, and by middle of February to 84.

Another set came to Wyk averaging 75, and increased to 88 per cent. The following year they came again at 85 per cent. and reached 91.

It is quite probable that a large part of change here noted was seasonal (*Zeit. f. Kinderforsch*, 1911).

At Birley House Open-air School in 1912 percentages of hæmoglobin for the children on admission were : boys, 86·6 ; girls, 85·3. After 24 weeks these had become : boys, 89·1 ; girls, 88·7 ; and after 44 weeks : boys, 91·8 ; girls, 90·7.

By the same Tallquist method Chicago open-air school children in 1913–14 shewed 68 per cent. had gained, 3 per cent. lost, and 29 per cent. remained unaltered.

In various other American schools in the same period 79 per cent. gained, 4 per cent. lost, and 17 per cent. remained stationary.

Gain is everywhere greater in open-air classes, and it is a trifle greater among children who have no school feeding, and presumably, therefore, are somewhat better nourished. Clara Town, in her study of five- and six-year-olds, found 70 to 80 per cent. as the rule. Cabot gives 80 per cent. for children 5–15, and Josephine Young, 77 per cent. for supernormal children.

For many years, observations have been carried on in Leipzig under the auspices of the Teachers' Union, which did a great deal to advance scientific professional knowledge among teachers. Meyrick found a reduction in boys for first two, and girls for first three years of school-life. With the commencement of puberty there is some reduction among girls. Country children here, too, were noticed to have better colour than in town.

Backward children had more anæmia, but whilst anæmia and capacity seemed dependent, anæmia and giftedness had no relation, some of the cleverest being very anæmic.

One remarkable effect of the War was a steady decrease in the percentage of Leipzig children shewing anæmia. One explanation was that war food, wanting in fats, increased vegetables with iron, calcium and phosphorous salts. Another is that the volume of the serum is diminished with starvation, so that the relative number of corpuscles increases.

The results published have often a spurious appearance of accuracy, percentages are quoted to tenths, and it is doubtful, except in the case of the summation of large numbers, whether the error of experiment does not many times exceed the variation noted.

Tallquist's method commonly used is certainly not reliable within 5 or 10 per cent. in any particular case.

Dreyer has drawn attention, not to the seasonal variation, but to diurnal changes. The volume of the blood is easily affected by food, drink, exercise, or sleep. Dreyer puts the possible daily variation as 30 per cent., and 10 per cent. is common. The variation seems commoner, and greater proportionately, with low hæmoglobin content. He suggests 5 p.m. to 7 p.m. as the time when variation is least and when any observations should be taken (*Lancet*, 1920. ii. 588).

Seasonal effect proportioned to ultra-violet radiation has been noted by Hess in respect to calcium content and also phosphorous content, and recently effects on blood have been shewn from a single hour of exposure to sunshine.

The subject of blood structure is too technical to do more than allude to it here.

Dina Rabinowitsch, examining Berlin school children, found the leucocytes about the same numerically as in the rest of life, some 6000 to 7000 to the cubic millimetre. At the age of admission lymphocytes are about 60 per cent., but steadily drop to the adult

value of half this. Polymorphonuclears have the reverse proportions, rising with age from about 30 on entrance to about 70 per cent. of all on leaving. Eosinophiles range about 5 per cent., and transitional forms 2 to 3 per cent. The large mononuclears are, as in the adult, about 1 to 3, and (Basiphiles) mast cells 0·3 to 0·6 per cent. (*Arch. f. Kinderheil.*, 1912. 161).

Mendl describes anæmia of school children as distinctive and due to school, and that ordinary school doctor's examinations *ad hoc* are practically valueless. The changes are essentially qualitative (*Brit. Journ. of Child. Dis.*, June 1913).

Helwig of Zinnowitz examined blood in morning and afternoon, and like Dreyer found rapid variations, influenced by lessons and ventilation. He got degeneration products, poikilocytes and "Neubildungen," unusual forms of the red corpuscles. A short airing getting rid of these degenerate products, which even long marches had less effect than school-work in producing.

The Arneth index, ascertained by determining the sum of the cells in which the nucleus appears to comprise one or two main fragments, after 100 has been examined, possibly depends too much on accidental factors. It is supposed to represent relative rest of the white cells. It is raised in feverish conditions. The average European index is 40, but Australian children give higher values, ranging about 66 to 72. These values affect children all over Eastern Australia.

In regions such as the coastal districts of Queensland, in the southern half of the United States, in Central and South America, and wherever the hook worm prevails, chronic conditions of grave anæmia are found prevalent in children, sometimes affecting their growth and dwarfing their mentality.

Anæmia in a school child is usually a secondary anæmia due to some chronic toxins. Most children with stigmata of hereditary syphilis, especially with deafness, have a considerable anæmia with a muddy tint of complexion; so, too, cases of latent tubercle are often suggested by marked anæmia and an earthy pallor.

Rheumatism generally expresses an exacerbation by anæmia of a somewhat lasting nature, and when there is a prevalence of diphtheria the search for carriers is best directed to those with obvious anæmia. Tonsillitis and dental sepsis, in fact any of the cryptic septic foci, may have to be looked for as an explanation for persistent anæmia in a child.

Temperatures.—On the temperature of children it is difficult to get accurate information. Dr. Bardswell published (*B.M.J.*, 1911. i. 1107) records from nine healthy individuals, shewing a steady rise from 97·1 at 4 a.m. to 98·4 about 10 a.m., 98·6 by 6 p.m., then a fall to 97 or below by 2 a.m. This represents the daily variation.

The ordinary school child often shews a fraction of a degree

above the normal 98·6 or 98·9 ; probably the majority will register 99. Mrs. Williams, in 466 cases, found taking one-fifth of a degree divisions the children from 98 degrees upwards as 5, 1, 64, 13, 29 ; 87 at 99 degrees, 61, 51, 46, 40 ; 40 at 100 degrees, 17, 5, 1.

Dr. Abt (*Illin. Med. Journ.*, 1919) points out how liable neurotic and apparently normal children are to raised temperatures. The condition is easily induced in convalescents or others with low septic conditions of ears, tonsils, or so forth. Unless acute disease is suspected, the temperature is likely to be normal in an hour.

In Pearson's Draper Research Memoir IX, average temperature is noted as falling nearly a degree during school-life ; that of poor children is higher but variability greater.

St. Leonards girls made 98·4 and $\frac{6}{2\,3\,4}$ exceeded 99 degrees. Charterhouse boys made 98·4 and $\frac{1\,1}{4\,8\,7}$ exceeded 99 degrees. Winchester, 98·4 and $\frac{2\,8}{3\,2\,4}$ above 99 degrees. In the Worcestershire Primary schools boys made 100 and $\frac{1\,3\,3}{1\,5\,3\,1}$ below 99 degrees ; girls, 100 and $\frac{1\,0\,9}{1\,8\,1\,1}$ below 99 degrees.

The Rheumatic Syndrome.—For school purposes it is permissible to speak of a rheumatic syndrome. Recurrent tonsillitis, chorea, rheumatic fever, subacute rheumatism, and carditis with its adjuncts, are symptoms which, when present either singly or with others are more safely considered as part of rheumatic infection rather than any other cause.

Chorea.—The next member of the group, chorea, is itself a symptom complex, producing motor symptoms from irritation of the midbrain (Thalamus, putamen, extra-pyramidal motor-way) by various causes of a toxic nature ; and mental changes from irritation of higher centres. The causes of irritation may be infections, as that of epidemic encephalitis, or streptococcal from tonsils, teeth or intestine, but the commonest, and for school purposes the most important, is the chorea commonly associated with other rheumatic manifestations, what Sir Dyce Duckworth justly called, rheumatism of the brain. Unless there be other obvious cause chorea may always be regarded as rheumatism. It is often regarded as a trivial complaint instead of a serious portent. Its diagnosis is not always satisfactory. A County Council Report in 1921 has a medical officer noting, " 10 per cent. among all examined were suffering from chorea or appeared to have already done so," but only 0·38 per cent. were given in the Report as having been referred for treatment for chorea, so that very slight symptoms appear to have been thus catalogued. Hadfield, paying special attention to the prevalence of rheumatic diseases in Bethnal Green schools, found 0·36 per cent. boys and 0·83 girls presenting some chorea, and in attendance. A careful enquiry in Lancashire gave 0·33 per cent. boys and 0·48 per cent girls. Many cases are, of course, absent.

Chorea, however, always merits a careful diagnosis, and if there is doubt the serious outlook must be taken. It has to be differentiated from signs and symptoms accompanying nervous instability, which is generally prominent in choreics.

In London one-tenth of the number absent were recorded as chorea, and 70 per cent. of these last girls. The excess of girls only appears at about 10 years of age. It is probable here that wrong diagnosis in the case of various tics and nervous habits and instability, has largely to do with the excess both of girls and in the prepuberal ages. There has been no diminution of the rheumatic and chorea absences for years.

Overflow nervous signs in a child prematurely set to do fine finger-work, for instance, the twists, frowns, and strains of fingers or tongue or face, are tonic and purposeful compared with chorea movements. From these may develop tricks of attitude and speech, and even spasmodic efforts like common face twitchings, so that various tics become involuntary actions. They are of a systematic character, the same performance being repeated, and generally at much longer intervals than choreic actions. They can be removed temporarily, sometimes permanently, by simple or hypnotic suggestion ; and can be cured by re-education, by making the performance a deliberate and voluntary action, thus often removing it from the subconscious realm. In rare cases psycho-analysis may be needed for a permanent result.

A form of psychic chorea, which reacts to the above treatment, has been described by Haberman (*Pediatrics*, March 1915), and imitative chorea reacts in this way. Hysteria may cause trouble, but in a child where there is doubt chorea is probably the solution.

The onset of chorea is generally insidious. The child in school undergoes some change in respect to work. It seems to become indifferent or bad tempered, peevish, or silly and giggling. It may become distinctly emotional in all responses. Some alteration, at first in the cleanness and neatness of sums or exercises is noticed, often ascribed to naughtiness or laziness ; involuntary movements begin to shew in writing. Mentally too, the choreic child will often give absurdly wrong answers, make mistakes in counting and so on. Memory is seriously impaired, and there is considerable temporary lowering of the intelligence level, with a corresponding loss of the power of attention.

Clumsiness and awkwardness are apparent. Dishes may be dropped or ink spilled, and there is a weakness in muscular tone in the face, or in slouched and huddled-up postures, which shews most in older children. Choreic movements, drooping and shrugging shoulder, jerks of head or of facial muscles begin. Twitchings of fingers are often to be felt before they have become visibly obvious. The tongue generally large and flabby comes out like a dart, and

disappears as if with a spring. The child may appear distracted or indifferent, sometimes it seems rather amused. The superficial aspect of cases varies much according to whether a mental, emotional, motor, or cardiac behaviour will be most prominent.

W. B. Swift notes a voice sign, the child being taught to repeat the broad â as in âre, and told to hold on to it. This is repeated half a dozen times. If there is the slightest contraction of the vocal chords the pitch of the â sound is at once raised (*Am. Journ. of Child. Dis.*, February 1915).

The ill-balanced emotional condition is better realized than described. The choreic child is almost always of a neuropathic type, liable to suffer from night visions or headaches. It may, indeed, be regarded as the reaction of this type to rheumatism. Poynton regards it as a rheumatic meningo-encephalitis ; fatal cases shew an encephalitis. In recent years it may have to be distinguished from the late result of polioencephalitis. History is of importance for this. The onset does not often concern the school doctor, but one of the most common diagnoses for early encephalitis lethargica is chorea.

It is this nervous type which may have given rise to the idea that chorea is due to fright or shock. In actual statistics this cause appears more rarely than is supposed, probably not more than 5 per cent. At Great Ormond Street Hospital during the air-raid period of the War, there was much less chorea than at other times ; possibly due to the War rationing which did an almost incalculable good to English children.

The neuropathic type is of a somewhat better social rank than most, but there is no doubt that rheumatic diseases are chiefly diseases of poverty, and chorea follows the rule. It is rare in private schools, but common in the public elementary school.

Chorea may occur at any of the school ages, but clinically is most frequent about the age of 7–8. There are practically no deaths from chorea below school age, but three-quarters of the mortality is during school years. It is nearly thrice as prevalent among girls as among boys, usually being seen in a thin, ill-nourished girl. In New York 26·2 per cent. of chorea was noted among those suffering from malnutrition, as opposed to 3·6 per cent. among the others, of 1400 children examined specially (*Buffalo Congress Report*, v. 268). Indigestion is a common symptom among them, apart from treatment by arsenic. Branson found 88 per cent. of his choreic cases with nasopharyngeal disorder and de Ponthiere has insisted on the value of surgical treatment of nasopharynx as a remedy (*Journ. of Laryngology*, September 1910). Some are suspected of tubercle.

Theodore Fisher followed up 53 cases of chorea, only using those seen at least three years, and found after that time 32 without

any heart symptoms, although 6 had a rheumatic history; 2 had died of heart disease and 18 had organic disease of the heart; of these 8 had a rheumatic history; 1 case had murmurs at apex and base which could not be definitely assigned as rheumatic (*B.M.J.*, 1903. ii. 452). As a rule they remain in delicate health.

The importance of treating chorea as a major disease is not that it may be fatal itself, as it occasionally is, but that its prognosis is always bad. A single attack may pass, and leave no apparent damage, but a recurrence is common and endocarditis is then too common, the mitral valve usually bearing the brunt, and a slow stenosis following. A rapidly growing girl is occasionally found choreic without any other possible trace of rheumatism. About a third of the cases of chorea are subsequently found to have carditis.

The number of cases associated with rheumatism is variable, but always considerable. Batten found that a third of 115 cases he noted at Great Ormond Street had a separate rheumatic history, three years later they had 43·5 per cent., and three years further on 53·2 per cent., but as 38 could not be found of the 115, if they were affected like the rest, 60 per cent would have had to be written down with rheumatism (*B.M.J.*, 1903. ii. 449).

Fraser at Paddington Green Children's Hospital, got a family or personal history of rheumatism of 90 per cent. in 300 cases (*Practitioner*, March 1912). The outlook for a rheumatic child seems on the whole better than for one with chorea (Forssner, *Jahr. f. Kinderheil.*, 1910). Dr. Marion Burt, in Birmingham, found the average absence of cases of well-marked chorea 41·3 weeks in 2 years, and minor cases 29 weeks (Report, 1923).

With this serious disease what is to be the school treatment? All choreic children are potential cardiacs. Many years ago Dr. Sturges wrote a book, the burden of which was that chorea was a school production. The writer agrees with Cecil Wall (*Lancet*, 1920. ii. 1081) that it is not good for a choreic child to attend school, but difficult to get any evidence that school-work is responsible for making a healthy child choreic. Choreic children are too numerous, and too protracted as cases, for the voluntary hospitals during convalescence. In many cases their homes are unsuitable, but school attendance would be disastrous. There should be sustained care and provision for these children. A special type of school is necessary, no child should be in the ordinary school under six months from the disappearance of choreic signs. It should be included in the cardiac school. Dingwall Fordyce has insisted on the necessity of seeing a choreic child through the mental adjustments of puberty, and providing for them a careful introduction to the responsibilities of life. He suggests a trade school for these children, worked with a wise non-meddlesome policy. It would be well if such a "non-meddlesome" school could be interpolated as an orienting mechanism, for

about three months between primary common schools and secondary schools for specialized education, not merely for cardiacs but for all children, to aid them to adjust themselves to a communal life. An attempt to ascertain the prevalence of various manifestations in children who presented evidences of rheumatism and were in attendance at invalid schools, was made in the L.C.C. Report of 1910, p. 136. As far as obtainable the frequency of various rheumatic manifestations was as follows—and of course this only holds for the very selected class actually in invalid schools—

TABLE 56.

	Numbers.	Percentage in all Children.	Percentage amongst Rheumatic Cases only.
Rheumatic fever	42	1·6	31·6
Chorea	18	0·7	13·5
Rheumatic tonsillitis	32	1·2	24·1
Growing pains	35	1·4	26·3
Heart affections	115	4·5	86·5
Obvious valvular disease ..	74	2·9	55·7
No reliable data	10	—	—

Etiology of Rheumatism in Children.—Rheumatism, although only rarely expressed as the acute articular form at these ages, is the most serious danger, both immediate and remote, to child-life at the school ages 5 to 14 years in England. Poynton notes that it is much less virulent in America, but there, too, it is a deadly threat. It does not come indiscriminately, there is a preponderance in certain families. Families of rheumatic patients at the Massachusetts General Hospital shewed about twice as many cases as families of non-rheumatic (Falkner, *J.A.M.A.*, 1924. ii. 426).

A vague heredity is noticeable, increasing with the severity of the cases, and in the bad cases heredity is generally marked. Cheadle, from his private case books, found 60 per cent. presented rheumatic heredity. The fact of a parent or brothers or sisters shewing rheumatism is sufficient ground for special instruction as to watching and resting a child in whom rheumatic symptoms may appear.

Rheumatically disposed children are often comely and well grown. Hutchison notes their square, shapely teeth. Brunettes seem to preponderate. In the Lancashire Report for 1919, a correct picture is drawn. "Rheumatic children can often be pointed out in school by their white faces set in frames of dark hair." From a memory of hospital cases in Yorkshire, red hair seemed to be a frequent accompaniment. Dr. Still noted that of 80 red-haired children, 47 gave a rheumatic history.

The converse, however, is shewn in 335 children selected by the school doctors as rheumatic, out of 3539 on the rolls in certain London schools of whom only two were noted as red-haired. Unfortunately, we do not know how many others were red-haired of the non-rheumatic 3104 remaining. Coates and Thomas (*Lancet*, 1925. ii. 326) report of 44 cases selected at random in Bath schools as rheumatic, 6 were red-haired.

There is no marked seasonal prevalence. In New York Dr. May Wilson thought the cases evenly scattered through the year except the Autumn period, when only 7 per cent. occurred. An almost epidemic prevalence in London in 1919 was reported on in connection with 172 cases for a year at Great Ormond Street, the chief incidences being during the Autumn (*Lancet*, 1920. ii. 1086).

Greenwood (*J. Hyg.*, 1908. 171) analysing admissions to the London Hospital for thirty years found cases of rheumatic fever most common in the Autumn. The Registrar-General's Returns shew deaths from rheumatic fever slightly more prevalent in Spring. In the Glasgow Children's Hospital there is a distinct peak in October and November (Bertram, *B.M.J.*, 1925. i. 497) in both chorea and arthritis.

Locality of old water courses in London was shewn by Dr. Jean Shrubsall on a spot map of rheumatic heart cases, and increased prevalence coincided with nearness to the river fronts in New York, according to Dr. May Wilson (*J.A.M.A.*, 1924. i. 759).

Rheumatism, although not a poverty disease, is very uncommon among better-class children. It is rare in the great public schools, but common in the elementary schools. The age distribution is difficult to assess, as only the worst cases usually find their way to hospitals. In the epidemic, the numbers of cases at Great Ormond Street rose steadily to 7 years of age, then fell to 12. Dr. Langmead (*Lancet*, 1911. ii. 1133) took every precaution to secure accuracy in his examinations of four North London schools. He found 5·2 per cent. among 2556. In another examination, where school doctors filled a separate card for each rheumatic child, 10 per cent. were noted in over 3000 children. The evident cases are few in the infants' department, perhaps 1 per cent. by the age of 6, but steadily increase till, in the average elementary school, by the age of 10 or 11 about a tenth of the children may be classed as rheumatic. Taking every case into account, Mrs. Williams in Worcestershire notes about one-third of her children as rheumatic.

The diagnosis of rheumatism is important and difficult. Influenza in the past generation has added to the difficulty. The importance of rheumatism lies, as in myopia, in the large number of trivial cases, but of these a certain number, without the greatest care and attention, will go wrong and result badly through no fault of their own. It is only by collating and assessing signs and symptoms,

in which it is little things that tell, and no one of which may be pathognomic, that a decision can be made, and then in half the cases diagnosis will remain doubtful.

Whatever be the interest in arriving at correct statistics, or a general idea in this disease, without the slightest doubt it is to the child's interest to treat for a time as rheumatic.

The seven- or eight-year-old scholar who is pale and nervous, who has some slight feverish attacks and a rapid pulse, when first seen, may suggest half a dozen different things, influenza, pneumonia, meningitis, and so on, but if a few months before there has been another illness, somewhat like this, it is almost certainly rheumatic.

In hospital cases the commonest of early rheumatic happenings is chorea, but in the school child probably "growing pains." Vague and indefinite to found a diagnosis on, yet about half the cases recorded have only this. The enquiry for "growing pains" must be made very judiciously. In the nervous type of child, at an age especially open to suggestion, a direct leading question will generally get an affirmative answer. The response must only be elicited in indirect ways if it is to be trustworthy. Without such precaution records must be discounted.

It is possible for a child to be rheumatic and have heart trouble without ever feeling any pain. Even if pains are described they may have been due to influenza or some other toxic cause. They are in the main rheumatic. Cheadle found a rheumatic history twice as common among those with growing pains, as among those free. Langmead found it common among those with pain, rare among the others. Some years ago Delcourt (*La Pathol. Infantile*, April 1913) stated that these pains were chiefly from the twelfth to the fifteenth years, and accompanied febrile conditions which compelled horizontal rest, rapid growth taking place. Any rapid growth in children may present such pains, and also often striæ of atrophic skin about the sides of the knee-joints. H. P. Newsholme found the pains referred to the front of the thighs in half his cases. They are popularly supposed to affect hamstrings, but only did so in about a tenth. Of 969 children examined as regards these pains, 37·4 per cent. had them, and of those family history of rheumatic fever was at least double as frequent as among control cases. Among children themselves tonsillitis was twice, and enlarged tonsils twice, as frequent as among controls. Dental caries was equally common in both sets of children (*Oxford M.D. Thesis*).

In the Lancashire Report for 1919, out of 1211 cases 25 per cent. boys, and 32 per cent. girls were assigned as rheumatic, but the Report states that half of these were classed on growing pains alone.

In addition to chorea, or recurrent tonsillitis, anæmia is another rheumatic sign.

Rheumatic nodules, taken as indicating much activity and of bad import in hospital cases, are scarcely ever noticed in school children, but they are scarcely ever sought. In an intensive study of a few cases, Coates and Thomas (*l.c.*) found nodules in 25 out of 100 children as controls at routine inspection, and in 35 of their 44 rheumatic cases studied.

The manifestations of rheumatism are undoubtedly due to varying doses of chronic poison from some micro-organisms not yet definitely isolated. The various local pains and aches associated with pyorrhœa and other focal sepsis suggest that rheumatism starts from a somewhat similar origin.

A slight but persistently raised temperature with increased pulse rate is a suspicious sign. The frequency of acute tonsillar inflammation, either as the immediate forerunner, or its frequent association with chorea, suggests tonsils as an avenue of infection.

Years ago de Ponthiere of Charleroi proposed nasopharyngeal operation as a mode of treating chorea which gave relief in from a third to a half of the cases he treated (*Journ. of Laryngol.*, September 1910) and Langmead, studying rheumatism (*Lancet*, 1911. ii. 1133), found abnormalities of the nasopharynx in about half the rheumatic cases, and 27·8 per cent. had already had operations, whilst another 7 per cent. needed them. Branson, taking only chorea as a definite entity, found nasopharyngeal disease in 88 per cent. He thought the commonest avenue of infection the tonsil, and next to it the nose (*B.M.J.*, 1912. ii. 1429).

One of the uncommon, but still well recognised accompaniments of a rheumatic outbreak is epistaxis, suggesting nasal congestion at early stages. Repeated sore throats in children may be taken as rheumatic. Poynton regards the tonsils as the chief avenue. Menzer, after working with vaccines, treats rheumatism as an affection originating in the upper air passages (*Deut. Klin. Woch.*, 1913).

Knowing the frequency with which abnormal conditions persist, even after scraping out adenoids and enucleating tonsils, recurrences may be due to insufficiency or impossibility of clearance of the initial foci about the nasopharynx or sinuses.

Treatment of Rheumatic Children.—The outlook for a rheumatic child is uncertain. So many children present rheumatism who escape unhurt, yet none can be regarded as safe. The younger the child the worse the outlook. Rheumatism in the young is often silent until the gravest mischief is accomplished. There is a current idea that rheumatism and tubercle are incompatible. Whether this is baseless or not, they are infrequent in the same individual. Its social distribution, however, suggests that it is one of the diseases due to disappear with improved sanitary conditions and bettered amenities in life. If the price, in increased rates for improvements,

is paid, the suffering from rheumatism and heart disease will almost certainly be diminished.

The prospects of a child are more serious with a family history of rheumatism. Some children get off easily, but in a very few both family and child seem saturated with the disease, and it progresses relentlessly.

The important thing is early watchful treatment and rest at once. It is in this respect probably that the results of rheumatism are so rare among the socially better classes and so common among the poor.

Attention to nasopharyngeal conditions is recommended, although the question of operation occasionally causing exacerbation of the toxic conditions may have to be faced.

When definite rheumatism, chorea, quinsy, or cardiac symptoms are active, rest is the first requirement, sometimes it has to be prolonged. Later the treatment is directed to any cardiac conditions which may arise.

The necessity for instruction of parents and teachers to appreciate rheumatic symptoms is so great that the Croydon Education Authority in 1912 issued a handbill, prepared by Dr. Meredith Richards, for school use, pointing out how easily rheumatism was overlooked in young children and the risks of serious results. The authorities were anxious to secure rest and treatment in the earliest stages, and however mild the attack. Woollen clothing was recommended.

All kinds of damp dwellings, damp soils, and moisture should be avoided.

Dr. Branson's observation as to recrudescence precipitated by swimming-baths is worthy of note, as this careful observer would interdict swimming for children with rheumatic tendencies.

Rheumatic and other Heart Affections.—Heart disease is the most important cause of death now registered, amounting to about 10 per cent. of deaths, and as a single assigned cause exceeds all others, including tuberculosis.

An American child at 10 years of age, according to the statistician of the Metropolitan Insurance Company, in New York (1925) is three times as likely to die from heart disease eventually as from tuberculosis. At 35, the probability of death from heart disease is four times greater for men and six times greater for women than from tuberculosis.

When these deaths are set out in age groups the curve of mortality is seen to present two peaks, the first of which coincides with the period of greatest rheumatism mortality and represents the early juvenile deaths chiefly due to that cause. The rest of the curve gradually rises with age, and is a composite group largely due to industrial and social wastage (Fig. 57).

The indications of this mortality is that about one person in fifty suffers from heart disease. Its prophylaxis is therefore one of the most important, as it is one of the most neglected tasks of Public Health. Even in the class of person who insures, 2 per cent. are rejected for life insurance on cardiac grounds. Public provision for early treatment is a requirement likely to repay any outlay in the added efficiency in the national life and saving in unemployment and insurance payments.

Various developmental irregularities are found in about one in a thousand of the hearts examined in school. Their educational treatment follows that adopted for other heart cases. There is

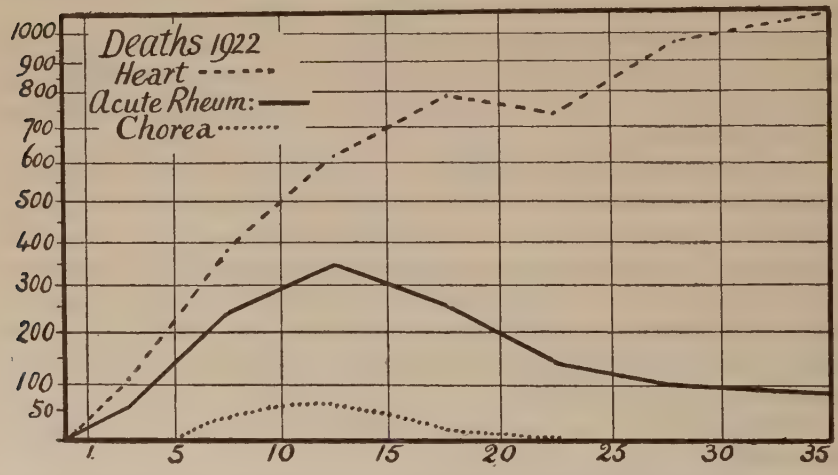


FIG. 57.—FROM THE REGISTRAR-GENERAL'S REPORTS FOR ENGLAND AND WALES.

no characteristic stunting of growth or malnutrition to call attention to them. Many are only found accidentally in medical inspection. The commonest form of pronounced congenital defect is that of pulmonary stenosis, and possibly chilblains the most obvious trouble. The blue children are about a quarter of those noted with congenital defect.

Although cyanotic and dyspnoeic, they are not mal-nourished. Mumford draws a distinction between the blue cardiacs who are usually well nourished, and those with blueness associated with feeble circulation and low arterial tension, who are generally debilitated and ill-nourished (*B.M.J.*, 1913. ii. 793). Of these about a quarter have rapid hearts due to debility.

The heart of a child is not always of one exact type. Its development and position varies with age. Up to the fourth year the apex beat is beyond the nipple line ; from fourth to ninth year it is about the nipple line ; and after that age should lie within this limit.

Muhlmann (*Die Ursache des Alters*, 1900) gives the following heart measurements—

Table 57.

Age in Years.	Absolute Volume of Heart.	Relative to 50 Kilos Bodyweight.
Birth	22·5	280·2
1½–2	42·5	213·0
6–7	81·5	231·0
14½–16	161·6	195·0
18–21	259·0	215·0
24–30	299·0	249·0

The Heart at Adolescence.—Just before puberty and roughly from about 13 to 15 the heart may double its volume in a year or two. This is a critical time, and adolescent variations are well recognized. Where a weakly or spoilt child complains of its heart, in the majority of cases, in spite of statements of pain or palpitation, no cardiac abnormality is found.

The disturbances are likely to shew earliest in girls. Nervous heart palpitation of a stormy kind often precedes the first signs of puberty, disappearing then, to reappear slightly with each period. These girls are often constipated and have digestive troubles, and they may sleep badly. Another form associated mostly with the long, thin, rapidly growing girl, who is neither nervous nor anæmic, is a cardiac feeling of fullness and shortness of breath. The heart is found to be beating strongly with a hypertrophied left ventricle.

In many girls' schools, possibly due to want of exercise, pale, anæmic girls with headaches shew heart insufficiency with dilatation, the apex being beyond the nipple line. On exercise the pulse rate may be almost doubled without particular shortness of breath, and recovers slowly on resting. German writers speak of a Wachstumhypertrophie, and French authors (G. Sée) write of a "hypertrophie cardiaque résultant de la croissance." It is probably the dilated, forcibly acting heart with a poor pulse due to endocrine readjustment. There is also the rapid heart associated with a definite temporary hyperthyroidism not infrequent among adolescent girls. A neurotic condition of heart occurs in some boys, palpitation with shortness of breath, and a pricking or burning pain about the heart's apex. Other boys present heart conditions like the effort syndrome as an accompaniment of puberty. They used to be rested in bed for weeks, but probably are best left alone but not heavily exercised. Poynton speaks of "inherited weak hearts," and the condition has been described by others as cardiac infantilism or congenital cardiac debility.

Schools of many stories' height find out these children, and on this account alone it would be unwise to build any school with more than three floors.

The variations in heart form seen by fluoroscopic examinations shew that there is considerable diversity in size as well as shape. A small heart is nearly vertical, and has been called tubular. They

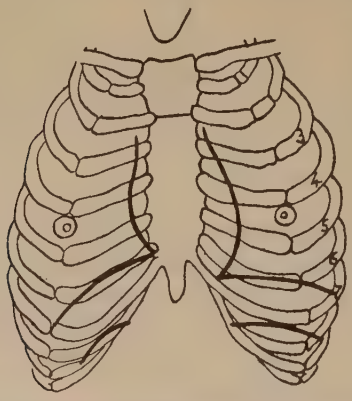


FIG. 58A.—THE VERTICAL, NARROW OR TUBULAR HEART.

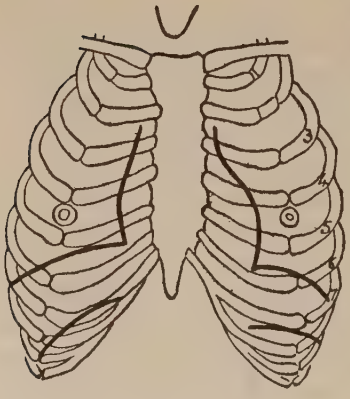


FIG 58B.—THE NORMAL HEART.

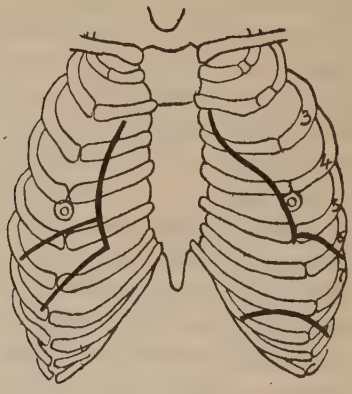


FIG 58C.—THE FLAT OR WIDE HEART.

are said to be commonly associated with pulmonary tuberculosis. In the Marathon race of 1910 the six men with small hearts all dropped out (*Am. Phys. Ed. Rev.*, 1911. 144).

With horizontal hearts five out of six finished, the one who dropped out being aged 52. Later experience has led to practical use of this knowledge. At Broken Hill in Australia the workers' hearts are examined by fluoroscopy, and all with vertical hearts are rejected for underground work (*Med. J. of Australia*, June 30, 1923).

Sometimes the want of development is mainly due to want of exercise. Meredith in a War study of 2000 women from 16 to 30 years old, found 40 per cent. with feeble but otherwise normal hearts. This he called myocardial subdevelopment. Nearly a third of these had been told to avoid all exercise on account of their heart.

The writer's own early observations suggested this when active boys were contrasted with pupil teacher girls in respect of cardiac efficiency (p. 68).

Within the past generation a change has taken place in views held as to the action of diseased hearts. Back pressure was formerly the chief theory, then muscle failure was of great importance, and now the causes of this have been traced back to infections poisoning nerves and muscle. These are not merely theories, but actual working doctrines of great importance.

Importance was attached to evidence of abnormal action of valves or alteration of rate. Next these conditions were analysed into functional and organic, and little importance attached unless dilation shewed that the heart, as it was thought, was failing. Now much less importance attaches to valvular signs without other conditions.

In children, rate may be irregular. Mackenzie has insisted on the youthful type of irregularity, which is really reaction of a sensitive heart to varying chest pressure, accelerating towards the end of inspiration, and slowing with expiration.

There is no single symptom associated with heart disease which a nervous scholar may not yield from quite another cause. Mere excitement of medical examination sometimes makes a child pant and palpitate. It may go pale, tremble, or faint; occasionally a systolic bruit is heard which later is sought in vain. Giddiness, palpitation, even anxious distress, rapid pulse, shortness of breath and various systolic apex or pulmonary murmurs, any or many, come at times in children who appear otherwise sound and healthy, whilst the real cardiacs are mostly thin and anæmic. The erethic child of the carnivorous type easily shews subjective "cardiac" symptoms with a healthy heart.

Some boys when first starting games, others just after games, have systolic apex murmurs which soon disappear. With any doubt, test the child's reaction to exercise, either by raising itself on a chair as in Flack's Air Force tests, or by the older test which from a score of years' usage the writer prefers, "arms upward raise, forward bend, touch the toes," repeat rapidly ten times.

Dr. John Priestley, who in the second decade of the century was responsible for some of the best hygienic work in English schools, detected variation from the ideal normal in four-fifths, and changes worthy of note in between 6 and 7 per cent. of all

children. His cases of organic heart disease numbered 676 in 70,000 routine examinations, a trifle under 1 per cent.

Some of the so-called hæmic bruits occur in well-nourished and even well-exercised children without anæmia. Dr. Leila Greig, in 1467 Staffordshire children with functional murmurs, noted only 16 per cent. as anæmic (*Staff. C. C. Report*, 1912. 51). They are generally cardio-pulmonary, and often vanish with change of position.

No systolic bruit should be considered certainly organic, unless there is enlargement, displacement, or a history or actual presence of other symptoms. Miserable atonic children may present a systolic bruit at the apex, not altered by position, yet soon remediable by food (school milk) and exercise.

In discussing exercise, dilatation of the heart is described as rapidly taking place when the inflow of venous blood necessitated outflow of more blood at each stroke, and just as rapidly as it dilates, so it reverts to its original size when the requirement is over. This is the emergency reserve of the heart. When it is insufficient, then the number of strokes has to be increased, but the quickening pulse is not nearly as powerful a mechanical gain as physiological dilatation, and its coming into play indicates that reserves are fully tried.

Where heart muscle for any cause has diminished in efficiency, the same process is used. Practically the only causes to be considered which affect musculature efficiency in children, are toxins in circulation. The heart with weakened muscle dilates, and may become more rapid, but with poisoned muscles the dilatation is chronic and indicates serious loss of reserve ; if with quickened pulse, it adds to the gravity of any other heart signs present. The ill-nourished child with dilatation often complains in a vague way of not feeling well, and headache is frequent.

Riviere first pointed out the considerable variation in normal hearts in boys and great variation in its size in connection with sustained efforts called for in school journeys (*School Hygiene*, 1910. 144). He concluded that most changes in shape, if they exceeded a half-inch, were more than physiological. He obtains deep dullness, by light but firm percussion with one finger, during quiet respiration. The right side was the earliest affected. After a school journey half the boys had dilatation lasting weeks. In the open-air school, among debilitated children he found dilatation out of all proportion to efforts made, especially in those rapidly gaining weight. He was impressed with unnaturally sustained exertion as a factor, contrasted with short, sharp bursts which are characteristic of the juvenile.

Children in country districts who walk a long way to school, often being debilitated, will complain of an aching referred to the

back, about the lower cervical vertebræ, and develop a chronically dilated heart, the feeble radial pulse being noticeable in contrast with the forcible diffuse heart beat.

In nearly all cases where the heart, whether normal or debilitated, suffers from chronic dilatation, it is from sustained effort. Such children were kept from school journeys in Germany till Roederer found that many gained in strength and weight if given light work. Mumford, too, notices how frequently boys suffer from want of development through this prescription of rest for the heart. He thinks ordinary Swedish exercises are best, but excuses boys with dilatation after febrile illness, appendicitis, or recent fractures or rupture.

Exercises such as running, jumping, or throwing develop the adolescent heart. Cricket would be a good game, although it would be doubtful whether the patient should be a bowler. All these exercises have intermittent effort. Heavy athletics—fencing, swimming, and cycling—dilate or hypertrophy a weak heart. Swimming often entails much loss of heat, but if it is done in warm baths at 70° to 80° F., this is guarded to some extent. With those whose fingers go white and dead, swimming should be cut out. Cycling is a very heavy exercise. Before the War it was said to account for 40 per cent. of the disordered hearts among German soldiers. Schott at Nauheim classed it as the heaviest sport on the heart.

Out-of-school work, where long continued and often associated with the carrying of weights, seems to cause cardiac dilatation. Dr. C. J. Thomas found (*L.C.C. Med. Off. Report*, 1906. 23) eight hours' work on Saturday as bad as thirty hours spread over the week. Recently cycling, carrying weights of 10 to 80 lb., has been noted as harmful to adolescents (Compton, *B.M.J.*, 1925. i. 51). Dilatation, possibly, is also a sign of chronic rheumatic conditions apart from over-exercise.

Parmenter, in the Hygiene Department at Harvard, found 10 per cent. of the students entering for athletic competitions had functional murmurs, and many had been restrained exercises, so that they had inadequate muscular development or physical stamina. By exercise under observation they improved, many murmurs vanished, and in five or six months, wrestling and swimming could be undertaken (*J.A.M.A.*, 1922. i. 1680).

Etiology of Cardiac Cases.—In examining a child's heart and recording findings from the point of view of the school doctor it is not enough to record anatomical description as deduced from findings. These findings—mitral obstruction, aortic regurgitation or whatever they may be—are useful records, but the two main things in the school child are : causes, with a view to prevention in others ; and present condition with a view to treatment.

The causes which constitute the etiology of heart disease may be grouped as:

Congenital defects.
Rheumatic, including cases with a history of rheumatism, chorea, tonsillitis, and rarely scarlatina. This group covers nearly all valvular troubles in the school child, and should be distinguished as active or inactive.
Diphtheritic.
Nervous, endocrine, and thyroidal conditions.
Other or unknown causes.

Halsey made a study of the etiology expressed in percentages of the cases seen in the New York Cardiac Clinics, and compared them with controls, the values for these last being given in brackets. He found 64 per cent. of cardiacs giving a history of tonsilitis, 64 (18); rheumatism, 45 (5); measles, 36 (58); pneumonia, 17 (9); whooping-cough, 13 (33); scarlatina, 12 (5); chorea, 14 (1) (*J.A.M.A.*, August 27, 1921). The excess of measles and whooping-cough among non-cardiacs suggests that heart troubles causes the sufferers to be more withdrawn from risks of exposure than normal.

The Liverpool Report for 1920 contrasts with this as it gives 70 per cent. as having either rheumatism or chorea, and 14 per cent. scarlatina; these being cases as seen in school, usually slight as compared with others.

Hecht, who compared scarlatinal and diphtheritic cases, found 66 per cent. post-scarlatinal cases sound years later, whilst only 22 per cent. of the diphtheritic ones had completely recovered (*Zeit. f. Kinderheil.*, 1924. 37. 5).

For the purposes of Public Health, rheumatism may be taken as the source of the acquired cardiac disease of school children, 80 to 90 per cent. according to American observers, although other septic foci may more rarely cause symptoms of pallor, petechiæ, fever, rapid pulse at rest and slow loss of weight along with valve troubles. Any prophylaxis is mainly the prophylaxis of rheumatism and chorea.

The structural condition of the heart should be next estimated and assessed as regards muscle, valves, pericardium, size, and position.

The diagnosis of heart conditions as seen in school is referred to incidentally elsewhere. Probably the condition which gives rise to the greatest amount of doubt is oncoming mitral stenosis.

Personally, palpation helps the writer almost as much as the stethoscope. The thrust of the apex is felt, sometimes with a thrill; perceived more clearly with the outer edge of the hand, the knock towards the end is characteristic in a well-marked case, and the low-pitched rumble of the presystolic murmur runs up to the knock. It may only be heard when the pulse is quickened or may

appear variable, and, having been noted, disappear. It can then generally be brought out by examining the child lying down after a little exercise. It is distinguished by its limited audibility just within or over the thrust of the apex. Possibly this is the most certain rheumatic affection, and yet the one in which often there is no other evidence of rheumatism, or indeed of any illness or defect until it is discovered.

With an irregular weak pulse, where there is doubt, fibrillation, as Lewis points out, may be distinguished, for if the pulse rate can be run up to 120 and the irregularity still persists, fibrillation is almost certainly present. It is, however, mainly in examination of young teachers that this question arises.

The prevalence of heart disease, its variation and amounts in the schools is not yet well known. Probably like rheumatism there is more among the poorer sections of the community.

An attempt to ascertain this in London was spoilt by other demands on the school doctors' time, so that it was inconclusive, but shewed that, neglecting absentees, not less than 1·12 per cent. of all had organic heart disease. There were 11 per cent. absentees, and it is known that 10 per cent. of absence was due to rheumatism.

In a valuable examination of four elementary schools, Dr. Langmead (*Lancet*, 1911. ii. 1133) determined that 4·49 per cent. of all, and 5·94 per cent. in the senior departments had cardiac disease. This was obvious in 2·93 and 3·92 per cent. respectively.

These figures are corroborated by the New York school inspection giving 1·5 per cent. Emmett Holt (*Arch. of Paed.*, 1917. 12) estimates that the cardiacs and potential cardiacs amount to 2·5 per cent. in New York elementary schools. Halsey's (1921) examinations of 44,000 children there, of whom 2·3 per cent. were returned as organic heart disease, confirm the estimate.

Priestley (1917), in Staffordshire, found about 1 per cent., whilst in Edinburgh they recorded 0·8 organic and 0·7 functional cases. If Berlin schools are taken for the years 1900–12 inclusive, the entrants aged 6 had 0·8 per cent., and at other school ages, 1·4 per cent.

Coming to older students, the women at Wellesley College, U.S.A., in 1912, had 3 per cent. organic, and 17·5 per cent. with functional disorders. In the American war drafts 3 per cent. were at once rejected, and another 1 per cent. on reaching camps, so that 4 per cent. of the young American men were turned down on account of heart disorder.

From many lists one concludes that the proportion of heart disease increases with age, and that girls preponderate. Apparently one in fifty school children require observation for heart disease, and 1 per cent. require special care not only to cut down the 10 per cent. of absence due to this cause, but later to send them out into life comparatively healthy instead of invalid. The majority of the

cardiac children at school, too, are without the urgent symptoms present in those who seek hospital.

The child's subjective feelings are of value when they spontaneously prevent muscular activity. The outlook in a cardiac case depends not only on the child itself, physically and mentally, but also on many surrounding factors. It is well to have an idea of the prospects of any particular case. The best judgment may be falsified in light of the events that follow, or completely upset by results of some fresh rheumatic attack.

Example is shewn by a young surgeon who, crippled by aortic disease after rheumatic fever in boyhood, yet so ordered his ways that he lived to distinguish himself through forty years, ere sudden death came upon him.

On the other hand, a training college student with very slight mitral regurgitation after rheumatism years before, which had apparently in no way affected his growth or athletic capacities, and who had no reason to fear the future, yet in the last term after three weeks of rheumatism became permanently crippled with aortic disease.

As regards the commonest valvular diseases, mitral regurgitation or obstruction, if slight, are compatible with long and useful lives.

The writer discovered an old lady to have marked mitral obstruction when seen for influenza. She stated that she had not had a day's illness since, at the age of 13, after four months in bed with rheumatic fever, she had had dropsy and a bad heart. This was sixty-six years before.

If, however, a child's mitral disease is severe or progressive, especially with stenosis, and if there is any shortness of breath or asystole, the prospect is bad. When aortic disease is present it has a serious outlook in children.

In cases admitted to hospital, the prognosis is serious. Dr. C. H. Dunn, of Boston, followed up 300 consecutive cases till 15 years of age ; 87 per cent. were rheumatic, 7 per cent. congenital, 3 per cent. other recognized causes, and 3 per cent. unknown. He concluded that the immediate mortality of rheumatic carditis is about 20 per cent., and subsequent mortality in ten years, 50 per cent. The final mortality of rheumatic fever in ten years is about 60 per cent. The cause of fatal heart failure in childhood is chiefly infection (*Am. Journ. Child. Dis.*, August 1913).

The enormous wastage through these diseases must always be insisted, or their care from the public health standpoint is likely to be neglected.

The Cardiac Efficiency.—Functional condition should next be stated as regards signs of failure, and also under the head of disordered heart action.

The great element in the school doctors' prognosis is not the

mechanical lesion of the heart, but the answer to the question, How does it work ?

Exercise tolerance, the testing of the heart's capacity to work without overtaxing its reserves, has been fully developed in the last dozen years as the real mark of heart efficiency. It is discussed in connection with physique.

Dr. May Wilson determined the effect on the pulse rate by making the child swing dumb-bells until the maximum amount of dyspnœa. The pulse rises from 5 to 100 in the minute ; in 57 per cent. it is normal in 2 minutes, and in 28 per cent. has dropped below normal, whilst fatigue and dyspnœa may still persist. The effect on blood pressure is a steep rise to a maximum in 20 to 40 seconds, and quick fall to pre-exercise level in 2 minutes. With the severest tests there is an increased rise prolonged from 50 to 70 seconds, and a slow fall to level in 3 to 5 minutes. This only applies, however, to normal hearts. Probst failed to find any delay in pressure in organically diseased hearts (*J.A.M.A.*, 1924. i. 2100). The delay in return to normal of the pulse rate is more reliable as evidence of want of efficiency.

Lewis states that deficient exercise tolerance is rarely ascribed primarily to the heart. With definite enlargement, or aortic disease or mitral stenosis or fibrillation, assign any distress to cardiac causes. In younger patients where no such evidence is present distress may be nervous, " heart strain," chronic pyogenic affections, or incipient tuberculosis (*B.M.J.*, 1919. ii. 621). No patient who has a normal exercise tolerance has grave myocarditis, and the gravity of the disease is proportional to amount of distress.

Dr. William St. Lawrence has classified cardiac children for social care, according to their exercise tolerance. Taking a wide outlook he recognizes a group of potential cardiacs as requiring consideration. He groups children for treatment and continued observation as follows, a grouping more practical but different from the New York Association referred to later.

To be seen once a quarter.

Potential cardiacs.—Children who have had acute rheumatism, recurrent tonsillitis or chorea, or joint pains.

First degree of heart disease.—Children with physical signs of heart disease, but no symptoms and whose exercise tolerance is normal.

To be seen once a month.

Second degree of heart disease.—Children with physical signs and some symptoms. Tolerance is subnormal.

To be observed in hospital ward.

Children with signs and symptoms of heart failure and absence of tolerance.

Lastly there is the group presenting—

Effort syndrome. No heart signs, tolerance diminished, and excessive circulatory reaction to exertion without evidence of cardiac disease.

The management of cardiac cases as a public social service had been without plan till the New York Association for Prevention of Heart Disease had the whole subject worked out by Holt, St. Lawrence, and others.

The first cardiac class was started at St. Luke's Hospital in 1915–16. The aim was twofold. First, prevention of infection and re-infection. Second, relief of the heart.

They proceed by eradication of possible focal infections, and building up of general bodily resistance.

At first carefully graduated exercises were used tentatively. The group of potential cardiacs taken into care had to be somewhat selected, purely as a matter of ways and means. All cases of acute rheumatism were taken. Cases with recurrent tonsillitis, myositis, growing pains or joint pains were only taken when two of these symptoms were present. Severe choreas were included. Mild chorea or occasional tonsillitis were refused.

All the slight deviations common in childhood, with systolic murmurs at the apex, along the left border of the sternum, or at the pulmonary or aortic areas, with nothing else pointing to the heart were refused. When less definite and influenced by respiration or position some additional factor is needed to make them significant, the enlargement seen in adults is rare in children, but where enlargement was seen, or definite valve lesions existed, they were accepted. Congenital cases and all pathological arrythmias were also included.

Of potential cardiac cases not under management more than half had their trouble due to rheumatic fever, only about 15 per cent. to chorea alone, and 7 per cent. to both causes. In potential cases under management all those who suffered did so through chorea. Mitral stenosis was the only valvular lesion observed to arise after the acute rheumatic process had subsided (*J.A.M.A.*, 1922. i. 947). The routine work of care was largely managed by social service workers, medical observation being followed generally as in the table of classification on the previous page. The child is admitted for forty-eight hours in an observation ward before being formally placed in the cardiac class. This saves much time and many visits. Observation is thorough. A four-hourly temperature is kept. There are blood and urine examinations. A Wasserman is done. The Schick test and if necessary a toxin antitoxin injection. A Pirquet test is made and a vaginal smear examined. The blood pressure is taken and an electrocardiograph. Fluoroscopy is rarely required.

The clinic and cardiac class to which the child is then passed is held once a week on Saturday mornings, so children attend without school disturbance. They are thoroughly examined at intervals determined by their classification.

All kinds of focal infections are sought out and remedied. Their effects are most marked in the second degree. General hygienic living is striven for, and if this is not successful, they are sent to a country home. With any manifestations of acute or active rheumatism the child is at once warded. In case of chorea nothing is known to prevent its recurrence. Prolonged stay at the country home seems best. The majority of failures have been under this head.

Exercise was at first cautiously used. After a time, with absence of bad results those with even serious lesions are urged to pursue normal lives. Children are instructed to attend to dyspnœa, palpitation, and tachycardia, and stop exertion with appearance of any one.

Probably exercise does no harm to the group with the first degree of cardiac affection.

The second degree with reduction of exercise tolerance is usually due to continued infection. The mother can well gauge the child's efforts on stairs. Under ordinary management tolerance should improve, if not it is put under graduated exercises. An exercise class at the hospital is attended three times a week, till reasonable tolerance is established, when the child goes home. Third degree cases belong to the hospital wards.

Calisthenics, which improve posture and carriage, are part of the work. It does not matter which muscles are used, circulatory reaction is the same. Children whose temperature reaches 99° F. are excluded from exercises.

The exercise group goes on for a quarter of an hour, then the tired drop out. The group continues till twenty-five minutes and more drop out, the rest have another five minutes, then mild games are played for a half-hour. Once a week each exercised child has its pulse counted, then this is done immediately after exercise for ten seconds, and again four minutes later.

The Committee which investigated special treatment classes in New York, thought after three years' experience (1924) that for tubercular, cripple, and mentally defective the small special classes were best, but for the rheumatic cases recommended that money would be better spent in securing improved diagnosis and reporting on, and following up, heart cases as far as possible in ordinary life. From experience of these clinics all the various rheumatic manifestations can be brought fairly under control, except chorea. The improvement is shewn by the marked change in absences from 39·9 days to 16·8 per pupil in 1923.

Many other places in America have followed the lead. Detroit, which does so well in school organizations, has less than 1 per cent. pupils with organic heart disease, but is saving its future citizens by cardiac classes for Group 2 children, taking them into

open-window rooms without segregation. The cardiac children benefit from it. They intersperse considerable rest periods in the day's work, and make much use of graduated exercises controlled by frequent tests.

Prevention by treatment along with other children in these open-window rooms is now the best method.

C. Cornell, in the *Health News of New York State* (December 1923), holds that experience already shews the enormous economic importance of this problem. Some types of heart disease are as truly preventable as typhoid or tubercle and these cardiac patients are among the most promising for convalescent care.

The feeling that cardiac cases should be spared effort is harmful. It is not exercise but infection which does harm. Only whilst the poisons are active does the heart suffer. The great remedy is education of children, parents, and teachers.

The standardized exercises for determining tolerance worked out by Dr. May Wilson, as tabulated on page 71, were an attempt to furnish a definition of " ordinary exertion."

The Association of Cardiac Clinics in New York in 1917 classified cardiac children and adults in relation to their exercise tolerance of ordinary exertion. Their classification was as follows—

Class 1.—Patients with organic heart disease who have never had symptoms of cardiac insufficiency under ordinary conditions of activity.

Class 2.—Patients with organic heart disease who have had such symptoms previously, but who do not have them at present under ordinary conditions of activity.

Class 3.—Patients with organic heart disease who at the time of observation have symptoms of cardiac insufficiency following ordinary exertion.

Class 4.—Patients with possible heart disease. Patients who have abnormal physical signs of the heart, but in whom the general picture or the character of the physical sign leads us to believe that it does not originate from cardiac disease.

Class 5.—Patients with potential heart disease. Patients who do not have any suggestion of cardiac disease, but who are suffering from any infectious condition which may be accompanied by such disease, e.g. rheumatic fever, tonsillitis, chorea, syphilis.

This classification is based on a functional diagnosis of the cardiac condition, that is, on the presence or absence of cardiac insufficiency as shewn by dyspnœa, distress, or fatigue following ordinary exertion. It is the last term which Dr. May Wilson has standardized.

The usual practice in England has been to admit the cardiacs who shew any sign of insufficiency to special schools for physically defectives.

Dr. A. P. Thompson (*B.M.J.*, June 16, 1923) wrote an account of the cardiac cases he took into the Baskerville Residential Cripple School on the following grounds—

1. Life in a cripple school is lived at a slow pace.
2. Rest in nervy children is promoted by example. The cardiac takes life easily when beside cripples in splints.
3. Rheumatic children do not do well with "blind unceasing rest," they become neurotic.
4. There is a great advantage in diluting the cripple school with a certain number able to help themselves.

A curious variation in the intelligence quotient in these children has been noted.

They found that elaborate control of exercise was unnecessary, and that simple dancing was a valuable exercise. Later reports shew children returning to the ordinary school and doing well. Dr. Thompson notes that about 15 per cent. of candidates for the open-air schools are rheumatic, and that a large number of rheumatic children have passed time in sanatoriums or other places for the tuberculous.

Wallace (*Am. Journ. Dis. of Child.*, September 1924. 282) used the stair-climbing test on 29 girls aged 7–17, selected from the Chicago Cardiac Clinics and sent to a camp school. He found that children recommended on history and examination as chronic cardiacs, with slightly diminished exercise tolerance, performed the normal activities of normal children easily and without evident detriment. The blood pressure and pulse rate to exercise is usually longer, and after a month of supervised rest, work, and play, although there was obvious general improvement, there was also a tendency to increase in these reaction periods.

As early as 1907, reporting on the heart cases in the London Invalid Schools, it was found that the doctors noted 107 as acquired, 17 as congenital, and 10 not definitely allotted, and made prognoses which could only be said to be good in 33 out of 134. In the following year it was stated that there were 271 heart cases and 46 with chorea. This last was responsible for serious loss of attendance. Children affected in this way are better for a year or two at an invalid school, where they are kept quieter and are under more strict observation. It was found that children who have suffered from repeated attacks whilst at the ordinary school can attend an invalid school regularly and remain apparently quite well (*L.C.C. M.O. Ed.*, 1909. 69).

In the following year (1910. 86), heart disease shews the highest mortality and accounts for more than half the deaths of pupils in these schools. In 1911 (Report, 158), Dr. Hadfield, by enquiries in North-East London, was led to the conclusion that "larger numbers of children than is usually supposed pass through rheumatism or chorea without heart disease appearing during school-life, or as he terms it, permanent heart disease. This, however, may not be a permanent escape, as after some years definite signs may appear,

and in older scholarship or pupil teacher candidates, the gradual development or definite valvular signs is noted occasionally in the changing heart sounds." Here the allusion was to the not infrequent discovery of mitral obstruction.

In the same report one case is noted where, of children selected for feeding, in the Isle of Dogs, the majority presented what the doctor regarded as definite valvular affection. This depending, of course, on selection by anæmia and malnutrition, unless discounted in this light, gives an unsound statistical proportion.

The pre-War conditions under which cardiac cases were admitted to Invalid Schools in London depended on clinical estimation of cases by the school doctor or medical inspection. They were classed as—

1. No organic valvular disease, but weak muscle after convalescence from such diseases as diphtheria or scarlatina, which may be protracted, and sudden exertions attended with danger, so that the re-establishment of usual school routine should be slow. Months may pass ere these children are fit for stair climbing or rough playground games.

2. Children generally presenting definite organic valvular defect. The congenital cases, estimated at about 14 per cent. of organic heart disease in school. The prognosis is bad, but a considerable number live many years after school-life.

Acquired cases, generally the result of rheumatism, make some 86 per cent. of the organic heart disease. Prevention of relapse or fresh rheumatic attack or chorea being important in these cases, their conveyance to school in the covered ambulance, avoidance of damp, and plenty of manual work is an aid. Then the usual school routine suits them well. All children classed as cardiacs must be taught not to be skrimshankers, usually they are the reverse. They need educating up to the simple instruction to do anything they like so long as they do not get out of breath, have palpitation, or feel very tired. Otherwise their work should be as normal as possible.

In a survey of cardiac cases in London Invalid Schools in 1909, in the previous three years 143 heart cases had left, of these 53 were fit for work, 29 for the elementary school, 3 for mentally defective special schools, 26 were physically unfit for any work, and 32 died. It was later estimated that 47 per cent. of these cardiacs in invalid schools had a reasonable prospect of normal existence.

One cannot forget a warning over a score of years ago by Dr. D. B. Lees, " Many a mitral stenosis in later life with its distressful years and its premature death might have been averted if the practitioner who attended the slight case of chorea in childhood had treated it rigorously as rheumatic " (*B.M.J.*, 1903. ii. 449).

The excess of rheumatism among the poor suggests that by

increased care and improving the amenities of life its prevalence can be reduced nearer to that among the better classes.

There is no possible escape from the conclusion that these rheumatic and cardiac children must be taken out of the ordinary school and kept under careful observation, and treatment of the conduct of life, protected from cold and damp, for many months or even years. An advance on our present practice is called for in England where rheumatism is so prevalent and so severe.

The co-operation of the home is required, but until school hygiene becomes educational, and is part of the school instead of an extraneous affair conducted by an assistant medical officer of health, in this, as in many other matters, there is little prospect of material advance for another generation.

Lacking reliable home care, as in the case of the cardiac girl regularly absent to do the family washing, the only reasonable treatment for active stages of chorea, rheumatism, or incipient heart disease is a residential school for cardiac children.

American workers have tried to evade this requirement by a combination of hospital and cardiac clinic, but American parents have reached an educational stage for which as yet we must wait. The residential school must mean active elimination of all sources of poisoning and necessary treatment.

The cardiac clinic might also be tried here, but for a time residential accommodation for cardiac children estimated for one and a half beds per thousand children on the rolls is an urgent requirement. And they are worth it. *Pereunt et imputantur.*

CHAPTER XVIII

MENTAL DEVELOPMENT

WHAT is in us that undergoes education? Any attempt to investigate this question soon leads to problems which have engaged the philosophers of all ages and to which there is no certain answer.

> Veil upon veil will lift—but there must be
> Veil upon veil behind.

Our aims are practical, and therefore we can simply seek a useful working hypothesis. We must remember first that life is manifested by changes represented by physical and mental phenomena, which are linked indissolubly. It is also necessary to understand that the part of mental life which we all seem to know, which appears as an entity in itself, is a small part of mentality, and yet on this part, as if it were the whole, is built all the superstitions and most of the ethical standards and working conduct of the world.

The mass of consciousness which I group together as myself, the Ego or I, means that I am conscious of something. It has several elements or aspects. Apparently the elements to which thought can be reduced are inextricably associated, in different degrees and amounts: cognition, feeling, attention. They are always present, and demonstrate that the mind works as a whole, in so far that no one of them can be isolated from the others. This knowing, feeling, willing, makes up the consciousness, which is associated in some way with every living body. It is a complicated whole arising from the grouping of life experiences.

Consciousness.—An ancient Greek first propounded that there was nothing in the mind except what came through the senses. By blotting out senses locally, consciousness can be locally abolished. Freeze a finger and all consciousness of it vanishes. By use of certain drugs such as cocaine, tissues exposed to their influence may become so insensitive and thus removed from consciousness that they may be pricked, burned or torn, without any sensation at the time. The poisons produced by disease, or even the violence of a knock on the head, may render us unconscious. A leg that has been amputated may still seem to be there and even to ache

or be painful. This arises because the nerves that carried its sensations still in part remain, and when their endings in the scar formed over the stump are irritated, the sensations are projected to the peripheral endings of the normal limb. The consciousness of the leg is therefore something central in the interpretation of sensations coming up the afferent nerves. These are simple examples known to most of us.

Sometimes unconsciousness follows a particular course suggestive to the educationalist, in that all events which have passed through consciousness for a quarter of an hour or twenty minutes before the unconsciousness occurs may be lost, having passed into oblivion. This is called regressive amnesia or pretraumatic oblivion.

Dr. Douglas Graham of Boston relates : " One evening at 9.15 I found myself in bed with my head sewn up. I asked my wife how I came to be there, and what had happened. She said that I was knocked down by a cyclist scorcher, and brought home in an ambulance by two policemen about three hours before. I have a dim recollection of getting off a car about ten minutes before being knocked down by the bicycle. Then there was an absolute blank of three hours. I walked from the ambulance with a policeman on each side to steady me, and my wife says I was very profuse in my thanks for their assistance, declaring all the time there was nothing the matter with me."

Although we are unaware of it directly, there is evidently some process going on in the brain, which takes time to accomplish, memorizing the events of consciousness at any particular moment. This action may be interfered with slightly, or the interference, if the cause be sufficiently great, may cause total suppression. This quarter of an hour is only the period of extreme change.

Elaboration of what may be termed the content of consciousness at any particular moment goes on by disintegration and reassembly, or association as it is called, for possibly days and weeks afterwards. The knowledge acquired for a short time before an epileptic fit may be entirely blotted out by a seizure, but it does not need such pathological causes to effect interference, schoolwork itself may act.

A series of nonsense verses learned in a certain time and soon utterly and apparently completely forgotten, if relearned some months later will be retained in a much shorter time than if never before seen. Some unconscious effect has been there and been retained. In educational practice this memory action is important ; if nonsense verses, for instance, are learned, and a task requiring close attention is given immediately after them, they are not well remembered.

In one case the task of examining pictures carefully was begun a few seconds after learning such verses, and an hour and a half

later, 28 per cent. only of the verses were retained; when the task was postponed for six minutes, 48 per cent. remained when tested later. The interference with association had been considerably diminished by six minutes' rest.

Another example may be given: An official who frequently had to write reports on many and intricate data, found great difficulty in the assembly of his report, if the work was immediately attempted after going over the facts. If having gone over them, he put the whole matter, without the slightest care or thought, on one side for at least four days, he could then sit down and write. Just taking what came into his mind, he could produce without any effort at analysis or criticism, a complete and balanced record of circumstances and required administrative action. All necessary examination of blind alleys, false conclusions, and wrong roads had been eliminated, and the best course arrived at; this being done by a perfectly subconscious mechanism which took about four days on its task. This process of association goes on the whole time without our realizing its action. Success of the brain as a machine depends on readiness of the action. Even such lowly subjects as movements of the hands or feet are thus continually learned. A skater can improve not only on ice but also during the following summer. In starting typewriting, a beginner, who has been away from the machine for a considerable period, may be pleased to find a few minutes after restarting that he is doing better work than before.

Apart from voluntary and conscious acts, there are possibly hundreds or thousands of times as many automatic and subconscious mental or nervous processes which are as important for life. Indeed, if consciousness is directed to these reactions, their full performance may be hindered, diminished, or even rendered ineffective. All cerebral activity, as Head states, consists of a march of events performed in part consciously, but to a great extent unwittingly.

When the mechanism is sought, it is possible step by step to go back to simple forms of life and still have evidence of sensation, which is a function of living matter. In its earliest development sentient action seems chiefly controlled by structural reaction to chemical substances produced in the tissues. In all organisms these so-called endocrines have to do with some fundamental nervous actions. They may, however, for the present be left over.

The greatest mental capacity is that involved in abstract judgments and the formation of ideals. This is a small part of mental life, and probably purely human. Such ideational mentality is the highest level attained. How small it is quantitatively is hardly realized. It is our conventionalized social life which makes the

intellectual appear so large in conscious life when it is only a part of a much greater whole.

The lower animals have a conscious existence and know much of their environment. They are capable of learning something by experience, but their mentality is limited and does not appear to pass beyond dealing with simple concrete facts by ways common to all of the same species. There is a lower stage in which sensation is followed by action that always is the same under similar circumstances. With it there may be a mental life of a sort, but not above the level of mere sentience.

Consciousness, as we know it, appears to depend upon the integrity of the lower cerebral ganglia. Its physical basis is

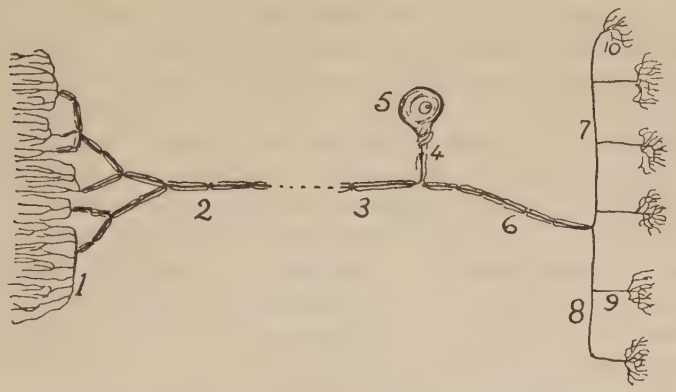


FIG. 59.—A SENSORY NEURON OF THE COMMON SPINAL TYPE.

1 Sensitive ceptors in skin, 2 and 3 the afferent nerve. The dotted interval a gap which may be inches or feet. 4 Nerve passing to neurosome 5 in the posterior root ganglion. 6 The spinal branch entering the spinal cord where 7 is the upper and 8 the descending branch, giving off collaterals 9, which end in mittors 10, bringing it into association with other neurons.

certainly in the cerebro-spinal nervous system, and not wholly in the cortex of the brain.

The Machinery of the Nervous System.—The activities of the nervous system depend upon myriads of neurons, of which it is built up; these are contiguous but not continuous. The neuron is made up of a cell body with nucleus and nucleolus; the cell body branching in many directions, the branches ending in fine twigs. The principal one of these nerve branches is usually much thicker and longer than the others. It is called the axon or nerve; the shorter and much branched twigs are known as dendrons or dendrites. The nerve cells vary in size from very small cells of 6 μ diameter to large brain cells of 70 μ (μ is the usual expression for 0·001 millimetre).

The purpose of the nervous system is to receive stimuli from

different sources, to associate them together in various groupings, and as a result, to execute movements and other processes to the advantage of the animal. These three functions may be called (1) afferent or sensory, (2) associative, and (3) efferent or motor. The processes are performed by nerve cells all working in co-operation, but each cell is specialized for one of these functions.

A sensory neuron has some of its terminals arranged to receive a specific kind of stimulus. The sensory end which receives the stimulus is termed a ceptor. It may be merely a fine filament sensitive to heat or cold, pressure or pain ; or it may be a special ending as the one in the cochlea of the ear, which is sensitive to change from the vibration of sounds ; other examples occur in the rods and cones of the retina, which are sensitive to actions from light or in the endings of the taste buds of the tongue and mouth. A stimulus from some source external to the neuron sets up a nerve impulse, which is afferent to the cell body, travelling up to it along the nerve. This nerve may be several feet long, but it is part of the neuron and through it the impulse reaches the cell body and then spreads out to the dendrons, which come into contiguity with other neurons. These dendrons end in mittors, through which the impulses pass to the ceptors of the other neurons, but are separated from them by a delicate mechanism known as the synapse. An impulse set up experimentally in a nerve will travel in either direction, but at the synapse it can travel only in the one direction from mittors to ceptors. So far as is known it is in these synapses that the selective action of the nervous system acts. The synapse is thus like the crystal or valve in a wireless circuit in its selective action on nerve impulses.

The cells to which the sensory neuron transmits its impulse, in the simplest nervous actions, are association cells : these bring it into relation with the efferent or motor neurons which send nerve impulses down their motor nerves out to muscles.

Suppose the tendon in front of the knee-joint, for instance, is smartly tapped, whilst a patient sits on a table with the legs hanging free. The tap slightly stretches the tendon over the hard bony surface and stimulates sensory nerve endings. One or more of these stimuli then transmits a nerve impulse up the sensory or afferent nerve to the sensory nerve cell body, which is in a ganglion, just outside and a little behind the side of the spinal cord. From there, impulse spreads by dendrons in the spinal cord to ceptors of an association neuron, which in its turn passes on the impulse to an efferent or motor cell, and this again transmits an efferent impulse down its motor nerve to the end plate, situated in the thigh muscle. This causes the muscle fibres to contract and makes the foot and leg jerk forwards.

This knee-jerk, as is well known, is useful in medical diagnosis,

as it indicates that certain nerve structures in the lower part of the spinal cord are acting in a healthy manner.

Such action is known as a reflex act or spinal reflex. It is not quite so simple as here stated. Other nervous mechanisms which control the tone of the muscles through the sympathetic system have to be inhibited, but we leave them out of consideration at present. This sympathetic arc has been put in on the figure in dotted lines. The simple spinal reflex represents action on what has been called the sentient mental level. A single small area is stimulated, without thought or voluntary effort, and quite unconditioned ; the result is an immediate small muscular contraction.

From the sensory cell which was first stimulated (S. I) some of

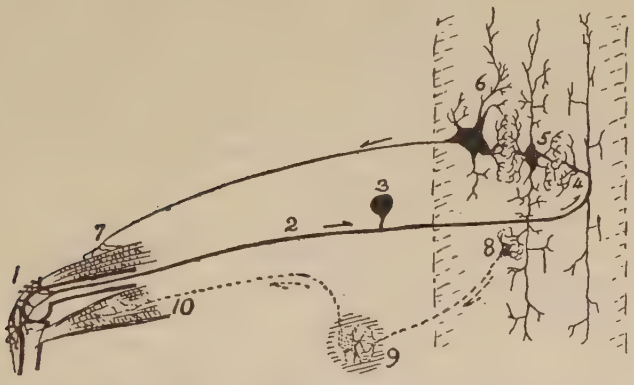


FIG. 60.—SPINAL REFLEX ARC OF KNEE-JERK.

1 Ceptors on tendon of patella, 2 the sensory nerve, 3 its neurosome, 4 branches in cord and mittors bringing it into contact with association cell 5, this fires the motor cell 6, and its mittors 7, causing extensor muscular fibres to contract. At the same time 5 also stimulates 8, the preganglionic sympathetic neuron, to send an impulse to 9, the sympathetic ganglion, whence 10 causes relaxation of the flexor muscle tone.

the dendrons branch to reach up in the spinal cord, or down, to other cells of a sensory nature (S. II) ; each of these last cells, which are connected with many cells of the I level represent areas rather than spots. They are connected also by many (A. II) association cells with (M. II) efferent motor cells which represent groups of muscles rather than mere muscle fibres. This II set of neurons is on a higher functional level, controlling and associating the actions of the lower I sets. These are the actions which have been classed as being associated with conscious mental life.

Conscious results are formed out of the compounding and associating of the various kinds of simple sensory stimuli into complicated automatic actions.

It has been attempted to set out a scheme of this cerebro-spinal nervous system, but the diagram is as if the British Army were

represented by a field officer, a non-commissioned officer, and a private. Some parts of the figure will be understood later.

At every stage of ascent in the animal status, there is increase in the numbers of associating or controlling cells developed in the nervous system. Each (S. II) sensory neuron may be thought of as linking up many (S. I) sensory cells. The same is true on the motor side.

Each of these S. II sensory neurons is not only brought, through many associated A. II neurons, into connection with many M, II efferent or motor cells, but also through their own dendrons are linked up with other sensory cells S. III, which bear the same relation to them that they did to the lowest groups. Each of these S. III sensory cells represents many S. II cells and through them very many more S. I cells. The sensory cells of this S. III highest controlling level are packed and crowded around with A. III, associating cells belonging to the same level, through which, relations can be established indirectly with almost any other neuron.

Inconceivably intricate and widely comprehensive combinations can thus be made in these associated groups of the III level. It is the level of conscious intelligence.

The Nervous Levels of Hughlings Jackson.—Dr. Hughlings Jackson accomplished a great service to humanity when he succeeded in disentangling the general mode of action of the nervous system. He shewed that as life had become more complicated all kinds of fresh arrangments developed, needing relay groupings to represent them, or rather to enable their association to the full extent necessary. These neurons had been intercalated in enormous numbers between the afferent sensory and the efferent motor cells of the nervous system. They form the greater part of the so-called neopallium of which most of the cerebral cortex consists. We see then that the great mass of the human brain includes large areas of association cells. This is necessary in order that a nervous action, beginning in a simple sensation, may reach the associating areas of the brain and give rise to exceedingly complicated results, which act in arresting or delaying the response and also associating it with any number of other actions.

This enormously increased power of association forms the great human advance in brain development. The groupings of both sensory and motor impulses, by the neuronic activities, are the foundation and material of all the ideas, theories, and hypotheses which the mind can construct; of these nervous activities is the whole machinery of mind, and without them it does not act. Even the all-embracing theories of Einstein, concerning time, space, and matter, are in the last analysis, a matter of sensations and muscular movements.

The oldest and most primitive nerve activities, like the spinal

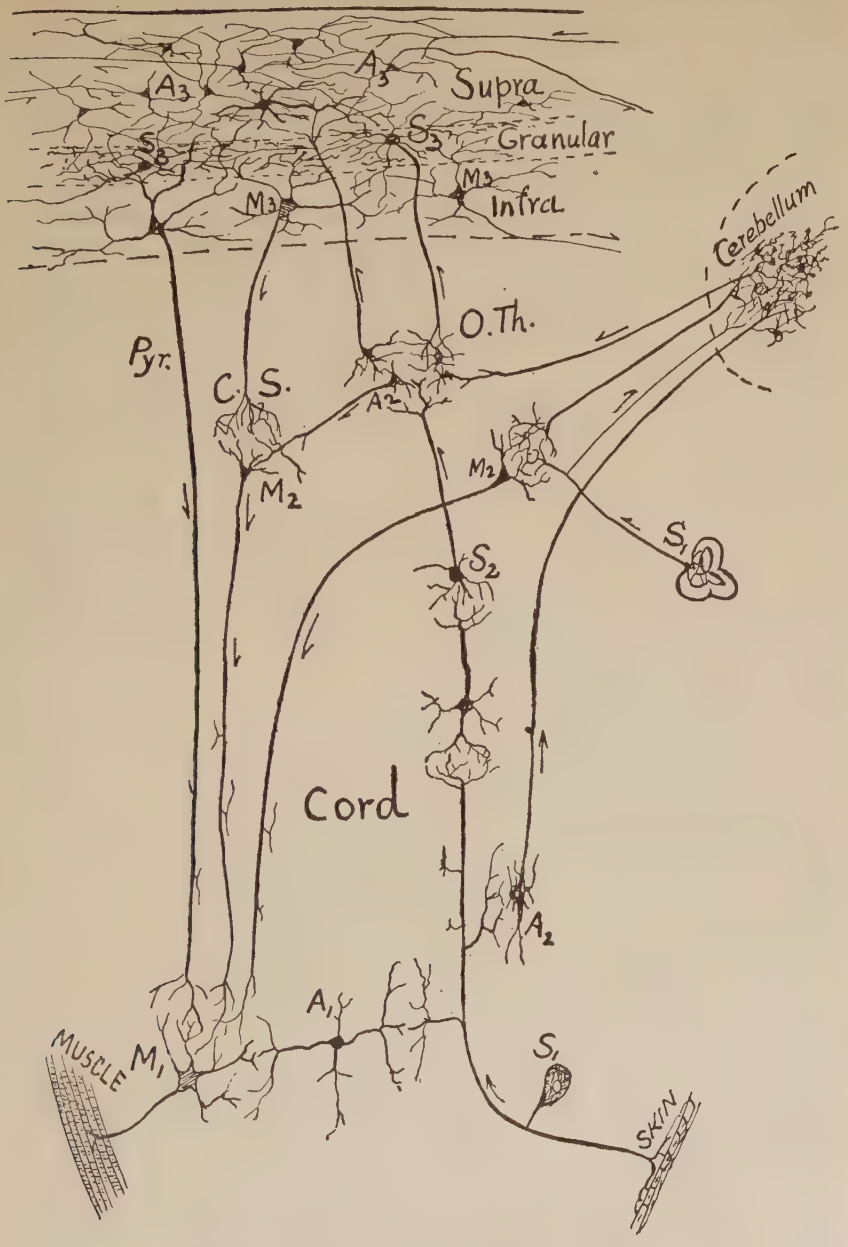


FIG. 61.—DIAGRAMMATIC SCHEME OF MAIN PATHS IN CENTRAL NERVOUS SYSTEM.

Sensory surface is marked skin. S_1 A_1 M_1 represents a simple spinal reflex. S_1 S_2 A_2 M_2 M_1 represents a middle level circuit. The automatic balancing action of the labyrinth is represented on one side S_1 high up. The ancient brain, cerebellum, optic thalamus, and striate bodies, and above them layers of cerebral cortex, whose manifold relationships defy representation. The ancient motor pathway can be followed, and on the extreme left the lately evolved direct pyramidal tract for voluntary action.

reflexes, are of such long inheritance that they are unchangeable and permanent. They are the groups already called I. This group of nervous actions Hughlings Jackson termed lowest level actions, using "lowest" figuratively in regard to the intellect. Although for convenience neurons have been referred to as I, II, III, in their order of ancestry, it is clearer to use the terms "highest," "middle," and "lowest" levels, so as to avoid any confusion as to whether I refers to highest or lowest level. One may say, picturesquely, that in consequence of information received, the cortex thinks out a movement (highest level) as an idea. The middle level cerebellum and ganglia make nervous connections subconsciously and automatically, so that various groups of muscles may act synergically, that is co-ordinated in time, direction, and force; and the lowest level spinal and corresponding cells make separate muscles act.

The lowest levels are thus regrouped by higher II cells, which Jackson called middle level cells of the nervous system. These consist of all cell groupings which manage instinctive and automatic actions without necessity for special thought or attention. They are also of ancient ancestry, and for this reason are fairly fixed so that it may be said they merely want opportunity to develop their utmost possibilities.

They again are controlled and managed by highest cells, sensory cells III, which regroup all those of I and II below them. The motor cells are similarly grouped, and both sensory and motor are packed and surrounded by myriads of association cells III, which enable the elements of sensation in the I group to be compounded into complicated combinations in the II level. These again are associated, synthesized, and abstracted into all kinds of complicated ideas, which finally are capable of expression through movements perhaps carried out over long periods of time, as when the centenarian babbles of his boyhood. Functioning of cells on this highest level is accompanied by attention and bright consciousness. If we may use an electrical simile, perhaps rather clumsy, but clear, the possibilities in the nervous system are such that the simple spinal reflex carried out through a circuit represented by the afferent sensory neuron, the association cell, and efferent motor neuron all in series, are also affected by this S. I, A. I, M. I circuit being shunted by II circuits in parallel. There are many of these circuits of the nature S. I, S. II, A. II, M. II, M. I. Again there are further variations possible, in that between S. II and M. II are further III circuits also in parallel with these lower circuits. These last, which may be represented as S. I, S. II, S. III, A. III, M. III, M. II, M. I, are multitudinous, and if we remember that there are all sorts of arrangements of these III circuits among themselves, either in series or parallel, we get a conception of

the innumerable and infinitely varied possibilities of nervous reactions.

So far the cerebro-spinal system, the only agent of voluntary action, has been referred to. There is also distributed throughout the body the machinery of an older system of reflex actions, the remains of a nervous system in use before vertebrate animals had developed, and before all the complicated association machinery has been evolved in spinal cord and brain. It is called the sympathetic nervous system. It controls and correlates the organic functions of various glands, and internal movements by means of nonstriated muscle fibres found in viscera. It is also connected up in slight degree with the cerebro-spinal system, and as in the knee jerk helps to control the *tonus* of the muscle. For the present muscular tone can be thought of as the maintenance of the *status quo* in any muscle. The sympathetic nerves are chiefly associated with older parts of the cerebro-spinal system in the basal ganglia of the brain, the functioning of which is associated with emotional feelings. This is exceedingly important and interesting, for in this way good working and proper action of every organ is subconsciously registered and regulated. The result is produced in consciousness, not as a discriminate sensation, but as vague emotional feelings of well-being or *malaise*. Such feelings cannot be located or assigned to a definite cause, but they yet colour and influence the background of mentality and determine temperament. They are the origin of such general feelings as joy or sorrow. The converse is true to a certain extent in that sensory actions and ideals have considerable although vague effects through the sympathetic system. The "open-air smile" is the result of good metabolism and a brisk circulation, as registered by the sympathetic nervous system.

Order of Development.—For educational purposes it is very important that the order of development of neurons should be known. The oldest, which subserve the most primeval functions are the sympathetic, then follow the machinery of spinal reflexes, and some of these become actively functional ere the child is born. It is possible to trace out anatomically the development of the cerebro-spinal nerves, as they possess a fatty myelin sheath, and and they are supposed not to be functionally mature till this is developed. Myelin reacts with osmic acid giving a black stain. Examining sections of tissues stained with osmic acid, neurons which are functionally active are recognized by their axons or nerves being shewn by black stain. In the course of development nerve fibrils of the cerebro-spinal system are distinguishable microscopically by other means about three months before they get their myelin sheaths.

At birth nerves in the brain, which stain black from the myelin

reaction, are nearly all middle level. Nerve sheaths are well developed in the cerebellum and about the medulla, but in the higher parts only few can be seen, about the region of projection of kinæsthetic movements.

FIG. 62.—SECTION OF BRAIN AT BIRTH, TO SHEW MYELINATED (FUNCTIONAL) NERVES STAINED BLACK.

Stained with osmic acid to shew the black patches where the nerves are fully myelinated. These shew in the cerebellum, to a slight degree in the ganglia and spinal cord, and just a trace about the upper part in the kinæsthetic projection region.

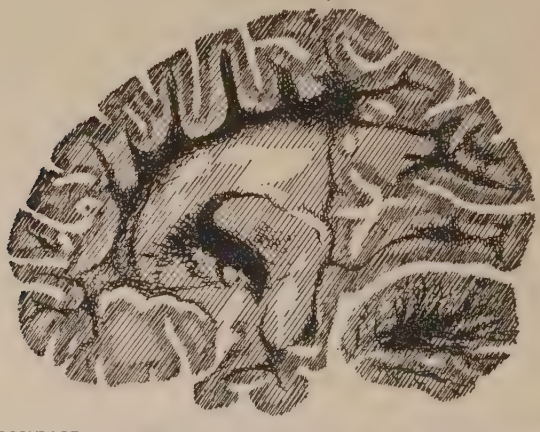


FIG. 63.—SECTION OF BRAIN AT ABOUT 5½ MONTHS, SHEWING FUNCTIONAL MYELINATED NERVES STAINED BLACK.

The myelination of the great voluntary movement tract through the inner capsule, and the kinæsthetic and visual areas and some of the association tracts, is noticeable.

Afferent nerves stain a little earlier than efferent. There is as yet no staining of the great motor path for voluntary movements in the internal capsule of the brain.

A section made later at perhaps five months now shews up the voluntary motor path. The whole nerve projection system of

areas, representing movements and ordinary sensations, particularly vision, are shewn in black staining, indicating that function in the nerves has reached them.

Flechsig, who suggested this method of determining the order of development of function of the various components of the nervous system, found that certain large areas, which he termed association areas, were very late in developing. Indeed, in some parts of the brain development goes on all through school-life, and there is even evidence that there is still development going on into adult life, although the growth in weight of the brain almost reaches completion in early school years.

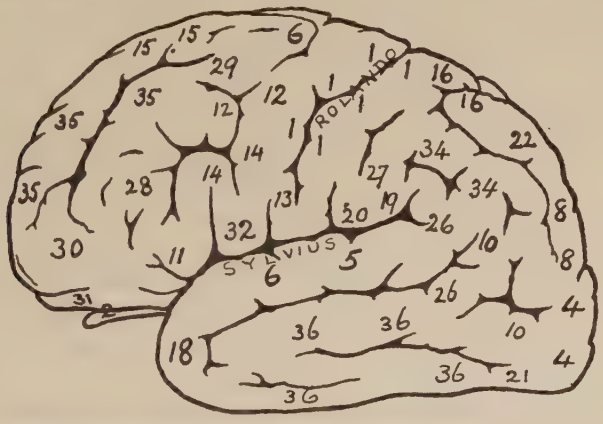


FIG. 64.—FLECHSIG'S AREAS AS SHEWN BY ORDER OF MYELINATION.

Left side view of brain marked out by numbers in the order of myelination as determined by Flechsig's method. "Silent regions" where associations are formed are the last to develop. 32 and 34 are regions concerned with speech, motor and visual. 35 the prefrontal region commonly associated with high intelligence. On the other hand, the kinæsthetic regions about the fissure of Rolando are the first to myelinate, and next the olfactory bulbs 2.

The figure of the left side of the brain illustrated has marked on it the order of myelination as determined by Flechsig. The early functioning areas being the kinæsthetic region about each side of the Fissure of Rolando, the visual areas at the tip of the occipital lobe and the region connected with the olfactory sense along the inferior margin of the fissure of Sylvius. The region usually connected with visual word memories is marked 34 and the pre-frontal lobes 35, whilst the two inferior temporal convolutions are 36, these being association areas of late development and high function in mentality. It is convenient to speak of these regions as centres, e.g. the visual word memory centre, but this is a diagrammatic way, and does not express the actual facts of associations bringing in many regions of the brain, and the so-called centre being a kind of junction.

One may turn aside, and speculate a little on the history of the neuron. A neuron, and the particular small collection or nerve centre of which it forms a unit, is not independent. The other organs of the body exist to serve it, but it is also wholly parasitic. Stop the blood to the brain for a second, and, the neurons failing, the individual becomes unconscious from syncope. Further, the neuron is subject to its environment depending for its growth and survival on the materials conveyed to it in the blood. For healthy untrammelled action, neurons must also have the waste products—so-called fatigue products, resulting from nervous activity—removed in the lymph ; hence free lymph movement and circulation is an essential requirement for healthy nerve cells. Primarily the neuron is simply a little round cell with nucleus and nucleolus. Some neurons appear to remain arrested at this stage, but most of them develop a projection, which grows into an axon or nerve ; later other buds throw out the various forms of branching processes or dendrites. These stages can be followed easily in the developing spinal cord of a young animal. Ross Harrison (*J. Exp. Zool.*, 1910. 786) has isolated undeveloped neurons of the tadpole and grown them in frog's lymph, watching them grow out and develop.

At first there is no specialized physiological function, then the axon develops and can be recognized microscopically, weeks pass and the myelin sheath appears, and till this has happened the cell is regarded as immature. Later the developing neuron comes into functional relations with other neurons, by the formation of synapses.

Nervous possibilities then find realization. Whilst the cells are yet immature and developing, function seems important for full growth. The cell owes its potentialities entirely to heredity. Form, shape, connections, mode of growth—all are inherited ; but without function they will not attain their full powers. Environment, and this includes education, can produce nothing that has not been given already by heredity, but environment can have a negative effect in hindering the development of these possibilities by want of exercise or nutrition. Want of food or want of play tends to produce weaklings.

Heredity is the creative power—the positive effect ; environment can create nothing—it is negative ; it can only destroy and prevent the appearance of powers which are latent. Even in young rats the diminished size of the brain was found to be due to an arrest by starvation in growth and development of the constituent neurons, by about 9 per cent. ; but there was no decrease in their numbers (N. Sugita, *Journ. of Comp. Neuro.*, June 1918). The neurons all appear to be present at birth, none seem formed later. Their rates of development are very variable, and their lives are not necessarily synchronous. Some reach maturity

early, some, indeed, are mature at birth, some disappear early, some last through life. An old Ulster man voted at the election in November 1924, whose nerve cells had been in activity before the battle of Waterloo.

Function Necessary for Development.—When a neuron is developing functional action aids its growth. The fibres of the optic nerves are not myelinated till the first three post-natal weeks. Neurons may be difficult to bring into action without strong stimuli. What is known as Babinski's test is where stroking the sole of the foot causes extension of the great toe, if the control of the brain (upper neurone) over the spinal centres is absent. This reflex is normally present for the first year of life, till control by the brain centres is established. The nerve centres for the fine muscles of the hands and fingers do not reach their maturity till about the middle of school life. This is important and too frequently neglected. The attempts of a child to do writing at an early age mean, to give one common example, excessive efforts at stimulation, efforts that overflow in many directions, causing the facial muscles to twist, the tongue to be protruded, all kinds of contorted attitudes to be taken up, before undeveloped centres can be brought into action. Fine finger actions or occupations in the infant school may thus cause excessive nerve strain; they should be allowed only intermittently and in moderation. At this stage, too, the material whose change underlies nervous action appears slowly formed in the cell, and not to exist in any reserve quantities, so that cells are speedily fatigued and even exhausted. A child's attention easily fails, largely depending, as it does, on the immature cells in late maturing frontal regions of the brain (35 on Flechsig's chart). With moderate and increasing use, cells attain their full maturity, their possibilities are reached, and explosive material is manufactured in sufficiency. They can then go on working, within reason, almost tirelessly. When old age interferes with their metabolism they again become easily fatigued and ultimately fail.

Attempts at further education are useless when the cell is mature, except in so far as the action of the cell, now almost mechanical in its perfection, may indirectly affect other structures. Exercises, mental or physical, which are not a little tiring or fatiguing in some respect, are scarcely educative. The educational impress received is directly dependent on some definite amount of fatigue.

The mature neurons are mere machines, always doing the same thing in the same way, without any improvement or change in their action. There are nerve cells, especially in the cerebellum, neurons which do not fully develop. They remain in the early embryonic stage without axons or dendrons. Probably they represent future nervous possibilities in the race in distant ages. Indeed, Watson has shewn in some of the lower mammals, whole regions remain

in this undeveloped condition, which, in the human being, have become completely organized. It may be the advance of some of these unused groups in brains developing a little irregularly, which give geniuses, those who astonish their fellows, or *idiots savants*, with one particular and extraordinary gift, but defective in most other directions.

Again, it was Hughlings Jackson who, in describing three functional levels of the brain, drew the generalization that the earliest of the neurons to mature are least subject to change, and last to be influenced by environment. The latest to appear functionally are also most liable to change and easiest to influence or alter for good or ill, by educational functioning or by adverse conditions of life. The highest powers of judgment, which influence conduct and control speech, are first to go, whether it be from the temporary action of alcohol or the permanent changes of old age. The effect of alcohol is a very good instance of action of a protoplasmic poison on the delicate structures of the neuron. The very highest judgments, performed by the neurons of the prefrontal region fail, and control of speech is diminished so that the tongue is loosened and things are babbled out that should be kept silent. The mid-brain becomes influenced and the balance of the eye becomes slackened through a disturbance of the muscles which maintain fixation of gaze and keep the optical axes of the eyes adjusted. The images do not fall on corresponding points of the two retinas, and things are seen double. The cerebellum, which controls the synergy gradually fails ; that is the exact adaptation of all the groups of muscles in complicated movements, and here the failure is first evident in eye and finger muscles. The great human attainment of hand and eye loses its co-ordination—then the limbs, so that the individual, if he rises up to walk, will stagger. If he does not attempt this and alcohol is still pushed, the body muscles gradually slacken, the head drops forward, the spine is bowed over, and ultimately the body slips on to the floor. If enough alcohol has been taken for the absorption into the system to be continued, the drinker passes into a stupor in which mere mechanical breathing goes on in a loud stertor, the individual is unconscious, "dead drunk." Ultimately even the lowest neurons, controlling such fundamental functions as circulation and respiration may fail, then the individual dies. If this final stage is not reached he passes, as he recovers, through a somewhat similar reverse series of stages, but here the recovery of the neurons often goes on during a heavy sleep.

Very comparable results occur roughly, but more permanently, from the poisoning of immature neurons by toxins of epidemic encephalitis. An infant may be rendered idiotic or imbecile. A school child has its conduct thrown back to the incontrollable

selfishness of the infant mind by the destruction of immature neurons of the highest levels, but it is not rendered imbecile ; there are usually enough matured neurons to prevent this.

The Cerebral Cortex.—For educational purposes the parts of the brain of the greatest interest and indeed the only educable parts, are those of most recent development in racial history.

Professor Mott, in his Bowman Lecture in 1904, traced out the enormous development, both in mass and complexity of microscopic nerve structures of parts of the brain surface known as the visual cortex. The anatomical position of eyes in animal history becomes more advantageous, and their functions more perfect, till in the human eye the attainment of stereoscopic vision is reached over almost the whole field of vision. The fore limbs, too, at first used only for standing, have further functions added, seizing food, and so on, till, in the human hand, the various simple movements can be combined in most complicated arrangements, with precision in time and force and sequence. With each of these organs, hand and eye, there is development of controlling nervous machinery, and, when they are gradually associated, this, as Mott demonstrated, stands out *pari passu* in enormous neuronic complexity.

The lateness of racial development of these functions and their high evolutionary status is shewn by the wandering gaze and want of co-ordination of eyes in the nursling, and, as Mumford points out, the uselessness of thumbs in the first six months of life. Indeed, the powers of the hand are only slowly acquired through school-life, and the handwriting does not become fixed till puberty. Ireland bluntly states that the best sign of idiocy is deficiency of the grasp.

Dr. Bolton studied the cortical structures in Asylum cases in relation to the nervous functions and conduct during life. He utilized all kinds of cases of epilepsy, dementia, and various conditions of insanity, and has set out wide conclusions extending the range and confirming Mott's observations. He regards the brain as grossly immature at birth, and growing to nearly adult size in the first two and half years of life, after which it slowly evolves in stability and complexity. Since these writers, Professor R. J. Berry, in Melbourne, by a combination of anatomical considerations, anthropometric measurements, and clinical observations as to the social and intellectual status of the individual, has attempted to utilize the older investigations as a practical means of assessing individual mentality. Following the almost diagrammatic expositions of Berry, we get a useful working picture of cerebral action.

The structure of the central cortex varies in the detail of different parts and is capable of anatomical description in seven or eight layers. Seen in mass a section vertical to the surface shews laminæ of grey matter covering the whole brain surface.

Over the region of visual cortex on which Mott's studies, above mentioned, threw so much light, there is a white stria about the middle of the grey matter, known as the line of Gennarius, made up by sections of bundles of axons, which are spread in a sheet parallel to the surface. Speaking generally, however, Watson, who examined the comparative anatomy of the cortex, refers to three layers, the middle one of which is called the granular layer, from the multitude of short neurons at this level. Below this layer with different forms of cells scattered through it is the oldest layer of the cortex, the polymorphic or infra-granular layer. It is developed throughout the mammalian group, and constant in mankind.

It is supposed to be the cortical nervous mechanism which controls the movements subservient to the various animal appetites, passions, and instincts. It has to do with the acquisition of the necessities of life, food, and sex. The struggle of civilized life is largely a conflict between primal instincts of the infra-granular machinery and their control by the supra-granular neurons, which determine social conduct.

The granular layer is taken as being mainly sensory, partly owing to its constancy but also from its being the ending place of entering axons. Above both these layers lies the supra-granular or pyramidal layer. It is almost peculiarly human, and very variable, but ultimately in full growth is thicker than the other layers together. Here the latest evolved structures are found, and for this reason it is the seat of the most highly evolved nervous function. This layer is almost wanting in lower animals, and is but slightly grown at birth, poorly developed in aments, and degenerated in case of dementia. It is especially thick and rich in the visual cortex, the posterior associational area, and in the peculiarly human pre-frontal area, the higher associational region.

This layer, then, is the educable part of the nervous system, and seat of high intelligence. Life can go on with this layer much damaged or under developed, when instinctive and automatic actions are still completely performed, and only the fine shades of conduct reveal alteration. It is scarcely realized what an enormous proportion of life's activities are instinctive and automatic. Thus, although manners and deportment early learned are subconscious and automatic, yet the fine control of conduct for social adjustment may be wanting.

The moral imbecile may be an extreme instance of such defect, but there are plenty of other examples. The mentally undeveloped apache of our large towns is one who is really a selfish and instinctive animal, knowing only anger, love, and fear, and uncontrolled by any fine considerations. Other examples are furnished by the child whose supra-granular development has permanently suffered

from the toxins of encephalitis ; and in later life by those whose higher neurones are degenerate from the chronic effects of alcohol on their protoplasm. In these cases emotions, appetites, and instincts are apt to be poorly controlled ; conflicts with social conventions and needs must then almost inevitably occur.

Berry shews that in the sixth month fœtus the infra-granular layer has attained 75 per cent. of its growth in thickness, the supra-granular only 25 per cent. At birth these values have become 82 and 60 respectively. This supra-granular layer constitutes a higher level basis for the carrying on of cerebral functions ; it subserves the higher thought processes, and is the layer through which education mainly works. The last layer to be evolved and to mature, it is the first to undergo retrogression, and such retrogression ensues when there is an undeveloped or too feeble use of mental powers.

At the same time this higher level is so shielded from observation by the automatic and subconscious mechanisms of lower levels that its action can only be inferred in a vague and general way.

Brain weight is a rough indication of mentality if we exclude the occasional cases where some hypertrophy of the supporting structures result in a macrocephalic, ordinary, or dull individual. Francis Galton shewed this for Cambridge students forty years ago. Berry and Porteus in Australia have attempted to work an intelligence estimate based on brain volume for various classes of people (p. 19). They determined cubic contents of the brain from cranial measurements, standardizing it with reference to age from some 9000 determinations.

In cases where brain volume falls into a low percentile for age, this is taken as presumption of poor development of the supra-granular layers, and is used as a check on any other tests for estimating mentality. According to these measurements, the brain in the first eleven years of life has attained 91·3 per cent. growth in girls, 88·8 per cent. in boys. Then follows a stationary year (pre-pubescent) of quite trivial growth. In the thirteenth or fourteenth years 3·4 per cent. for girls, and for boys 2·2 per cent. are added. After this, during the adolescent and post-puberal period, the brain makes up 4·7 per cent. in girls and 8·4 per cent. in boys.

Berry regards loss of education up to 16 as serious, as the stimulus to this final brain growth is wanting. He thinks that for about 15 per cent. of brains, growth is arrested at 14 for want of stimulus. This entails a loss wider and more serious than individual brain inferiority. In the end it means to the State that full control over animal propensities is not established and all kinds of social inefficients, delinquents, and prostitutes may result. He thinks

also that the supra-intelligent child, unless his brain is worked fully, loses the benefit of his high-grade intelligence for want of proper functioning at this critical period ; he becomes lazy. Bolton thinks the brain is only worked to a tithe of its potential capacity.

We know, however, that there is an education by living, whose results and effects are incomparably greater than any school educa-

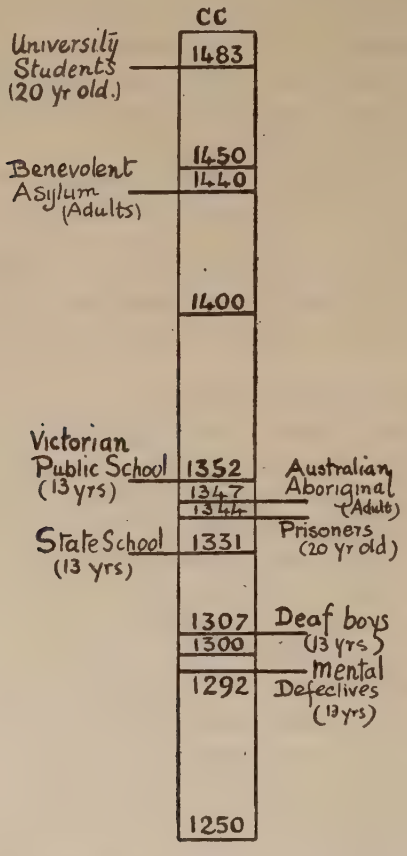


FIG. 65.—CHART OF CRANIAL CUBIC CAPACITY IN VARIOUS CLASSES OF MALES (PROFESSOR R. J. BERRY).

tion. The formal education will always be directed mainly to the conventions necessary for civilized life. The harm now is that even natural education is cut off by the systematized drive of civilization, which in many cases, confines individuals to a small and limited, perhaps very artificial daily routine, and deprives them of much of life's education.

Berry finally appeals to clinical medicine to bear out the value of his observations, and formulated a scheme for determining the social efficiency of the individual. This method of measurement

assigns the brain value of an adult aboriginal Australian, based on volume, as equal to a thirteen-year-old British school boy.

Many years ago, Pearson and Macdonnell concluded that craniometric examination was no guide to intelligence ; again, Professor Reid, in Aberdeen, after examining some 449 men students, failed to correlate the product of length, width, and height of head with marks obtained in examinations. In spite of these objections as an everyday clinical experience, relative small-headedness is associated with mental inferiority. Head measurements only indicate relative development of cortical layers of the brain, and cannot possibly measure intelligence, according to Berry.

In the chapter on growth (Fig. 10) it is shewn how mental capacity as measured by progress in school varies at various ages with physical growth, as determined by stature. Presumably brain volume varies in the same way, but Berry regards the variation as more related to this supra-granular development.

A different approach to the estimation of nervous functions in the developmental and adult stage may be made by the study of reaction to environment. It is this reaction which constitutes conduct.

Periods of Nervous Development.—The period of development of the nervous system may be taken as occupying three approximately equal stages in the first fifteen to eighteen years of life. Some children run through this development earlier than others. The clever, precocious, rapidly growing, big child will develop in less than five-year stages, others take a longer period, and some children may spread their three stages over six years each.

The first stage may be classed as that of feeding and digesting, eating and sleeping. In this stage, vegetative growth is the child's main purpose. At the end of this period, the brain has attained within about 3 per cent. of its full weight.

The next period is mainly of motor activities. In the earlier part the child wants to climb up, to slide down, and to run around. Later on he seeks, in addition to construct and make things with his hands, and wants to see how they work. During this time fundamental movements of the coarser muscular masses are undergoing many different kinds of regulative adjustments and control, which are aided by the coming into play of the accessory muscles and by the further development of the kinæsthetic senses.

The last period supervening in school-life is an intellectual period. This develops slowly till, at puberty, whole groups of emotions outcrop which undergo refinement during adolescence, giving a wider outlook and an intellectual grip of the universe around. Vegetative, Motor, Intellectual, these stages are rather to be regarded as convenient aids to memory than sharply marked natural divisions, they overlap and shade into each other.

These three stages of development with their differences and contrasts suggest an optimum time for obvious educational treatment adopted to each stage to safeguard and exercise particular functions requiring it. Thus, milk and sleep are more important than mental arithmetic for the babies. Games are better than grammar for the nine-year-old. In towns, where the ratepayers cannot afford sufficient contributions for playing-fields, side-streets should be scheduled, at certain hours, for childish activities. Only after these stages are safeguarded should academic subjects be considered important for serious study. Such a programme means

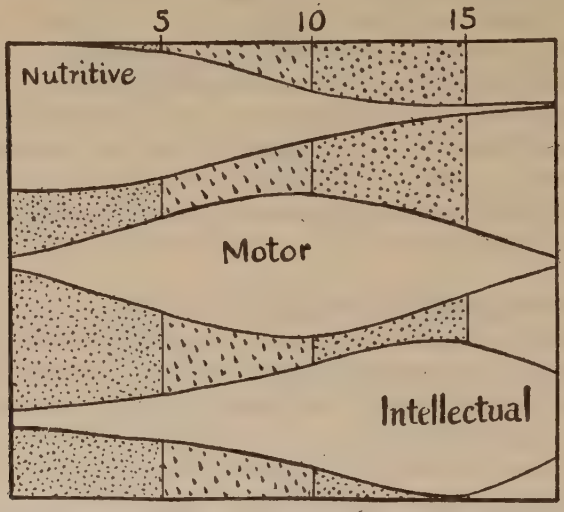


FIG. 66.—SCHEME OF RELATIVE RATES OF DEVELOPMENT OF VARIOUS NERVOUS FUNCTIONS, AT EDUCATIONAL AGES.

school till 16 for all who are worth full education, probably 66 per cent. of each year's crop of children.

Smell and Taste and Food.—We must now return to consider some further facts of development. The primitive sense-specialized part of the nervous system is the olfactory region. In many lower animals smell is important in search for food. It was only later, with evolution of hand and eye machinery, that the stereoscopic vision of the eyes became all-important as a distant ceptor of sensations for the nervous system. At birth, smell is still of greater importance than vision. The intellectual, discriminating brain destined to utilize vision has not yet come into functional existence. The infant at birth is a purely reflex animal. The nursling by a reflex act smiles when it feels or smells its mother. Other senses, too, probably in early days, play their part prominently and later fade. Taste is more dominant in the young than in the older child. Feelings generally are brighter and more brilliant in the

period of first dentition. Life's golden prime in the region of sensations is probably before school age. These incoming impulses are the bricks on which are laid the foundations of future mentality. Good sensation is not a matter of education, but may be a matter of good health. There is no such thing as training the senses. The actual visual acuity does not improve by training, nor the acuteness of hearing, nor smell, or touch, or any other sense. They are either there in their perfection of development, or they are obscured or damaged by disease. What is trained is intelligent discrimination and association.

The younger the children who are tested by correct means, the more acute is their hearing. So, too, the younger the children tested and the more care taken to eliminate extraneous errors, the higher the proportions attaining acute vision. The feeling fingers of the blind do not discriminate the two points of an æsthesiometer any better than the fingers of the seeing. What education can do is to train the mental interpretation of the sensations received. Even here it is possible, as many common illusions testify, to deceive the best-trained nervous system as to particular sensations of vision, hearing, or muscular sense.

Muscular Actions.—The great voluntary highway for motor impulses is through the pyramidal tracts which gather impulses, from motor regions of the cortex, that pass down through the inner capsule to the spinal cord, activating motor cells in the anterior horns of its grey matter. Destruction of one of these tracts means instant loss of voluntary movement in the muscles below.

These tracts, as shewn by Flechsig's method, are undeveloped in the newborn child. Yet before birth the same muscles were in vigorous action, while, at birth, the child can grip a walking-stick firmly enough with its hands to support its own weight. This gripping power is soon lost and is re-acquired only later. Evidently inherited nervous mechanisms are at work here. The actions are reflex actions, innate and independent of the will; the machinery which controls them is part of the ancient brain, acting before the higher central structures are evolved.

This ancient brain consists mainly of a sensory receptive region on the ganglionic mass known as the optic thalamus, and a motor part comprising the corpus striatum. At a later period these ancient nervous paths are sometimes evident in action as the results of disease or want of development in the higher cortical control. They act also in everyday life, in unobtrusive, automatic, and instinctive performances, which are as thoroughly carried through as if they had been carefully thought out. Muscular acts are therefore not only under direct control of the cortex through the pyramidal tract, but also find certain expressions in automatic action through the old motor tract.

This separate control may sometimes be evidenced in the course of development such as in the echolalia before speech in the babe, or later in the undeveloped brain of the moron. Further example is furnished by some of the cases, where loss of power in voluntary facial or other movement occurs, whilst emotional responses remain; as, for instance, in the case of a man who after a slight stroke cannot put out his tongue, but presently moistens his lips unconsciously with it. A more amusing example from the school was a small boy who had never been ill, except for a couple of days when a baby. He could whistle or smile to order, had all voluntary movements perfectly, but if threatened by a prick of a pin or a blow, showed anger only on one side of the face, whilst all emotional movements were absent on the other, which remained calm and unruffled, to the joy of his class-mates. The reverse conditions are occasionally found to exist in older people as a result of hæmorrhages about the central ganglia.

In the lower animals this nervous machinery acts in a reflex way, and is capable of but little change. It is more plastic in the human being. To a considerable extent, the influence of the cortex helps in developing its capacities. No muscle acts by itself as a result of cortical action. The higher centres act, not in terms of muscles, but in ideas of complicated movements. These movements, as we have seen already, are carried out by the arrangements developed partly through heredity, and partly through learning, in the cerebellum and lower ganglia. By this means all necessary arrangements for the performance of the act are made with the minimum expenditure of energy. When this is done, the act has been properly learned and soon becomes automatic, habitual, and subconscious.

In the ordinary muscular learning, which, as was stated on a previous page, still goes on in some degree by association even without muscular movements, the results of learning sometimes can be demonstrated by measurement. A certain stage is attained, then for a time no further progress. One set of reflexes has been trained but another remains. After a time the simpler movements have become automatic and habitual, attention is able to be directed to greater perfection; further adjustments are learned, so that another level is reached; perseverance and perhaps great effort are needed to attain a higher level, as still another set of nervous circuits are brought into the habitual action. Children come slowly into their muscular heritage. The infant's earlier movements are parallel movements of the limbs, swimming movements. It is about six months old before useful alternate movement begins, and a year old before walking is tried. Its fingers cannot use a cup handle till the end of the second year or later. On stairs the child gets both feet on one step whilst holding on. It holds on till

about 2½ years old. When it begins a year later to alternate feet it does so for a time holding on again. It is more than 3 before it catches a tennis ball, and bouncing a ball straight is a 4 years old performance.

Conditioned Reflexes and Habits.—To investigate and understand the nature of habits in the human being is a work of great importance. Habits are efficient brain actions to get the greatest result out of least effort. As we have learnt already, the cerebral cortex by its associative action can benefit by experience. This is important to the educator.

In his investigations on digestion, Pavlov found that sensations which happened simultaneously became associated in a common idea. When a dog was shewn a piece of meat its mouth watered. This is a lower level reflex, such as has already been described, only salivary glands, instead of muscles, are here stimulated. If every time the dog was given a piece of meat a bell was sounded the pleasure of the food was also associated in the dog's memory with salivation, so that later on the sounding of the bell, even without giving meat, caused salivation. Equally, it is possible to train animals not to do things, that is, to inhibit actions. This process Pavlov termed a conditioned reflex. It is conditioned by environmental circumstances in contrast with the ordinary automatic spinal or lower level reflex, not thus conditioned.

Probably all varieties of sensations can thus be associated with actions of various glands and muscles, or even in the human being with various ideas, as the correlative of states of glands and muscles.

Most education consists in the creation and development of groups of these conditioned reflexes. Professor W. H. Burnham has set out the value of the conditioned reflex for early education in Mental Hygiene. Florence Mateer has studied their production in young children. They are the basis of habit. Another investigator, Krasnogorski (*Jahr. f. Kinderheil.*, 1909. 1; 1913. 373) used the same method as a clinical test. He found that in neurotic children associations might be easily developed, but were dissolved only with great difficulty. Krasnogorski, recently in Leningrad (*Am. J. Child. Dis.*, 1925. 753), following up his earlier work, finds that conditioned reflexes, depending for instance on the discrimination of the different rates of two series of beats of a metronome, the nearer they get and more difficult to discriminate, the greater the nervous induction which seems to occur, so that the conflict becomes disturbing to the child's mentality. There is a tendency to delayed reaction, and intense general excitement may follow difficult differentiations, or conditioned inhibitions. This work appears to be bringing the fundamentals of conduct down to the plane of direct physiological observation. The whole gospel of

the modern psycho-analyst is found here ; a single nervous event may profoundly modify the child's nervous system for the greater part of a lifetime. Pavlov found that white mice might inherit tendencies to the conditional reflex. Whilst, at first, three hundred attempts were needed to teach the association, in each generation the number was less, till in the fifth generation, the association was learned after five tests with the bell. Some doubt, however, has recently been thrown on this work.

Golla (*Lancet*, 1921. ii. 115) shews how all reactions to stimuli are accompanied by faint muscular or glandular action. He regards thought, whether vocalized or silent, as a mode of movement. Any thought, even one of a stimulus inimical to well-being, is accompanied by action of the thalamus, causing a perfectly involuntary and specific fall in galvanic resistance through the skin—a reaction best observed in the palms or soles. This galvanic change can be accurately measured and timed in relation to the affective state causing it. He succeeded in shewing that the nervous system perceived the stimulus, differentiated it, and acted upon it before its sensory concomitants could be experienced by their affective reaction.

When a reaction has been repeated till it becomes free from indecision, so that the conflict between various alternatives which involve consciousness is ended, it has become automatic. It is now a conditional reflex which has been acquired, but the same cortical nervous mechanism is still used. Evidently learning until the action is automatic and subconscious does not mean that actions are shunted on to lower level of neuronic arcs, but merely that now they are perfectly performed, so that there is no indecision, no consciousness required in their performance.

This is the process of establishing a useful habit or inhibiting a wasteful one.

Plasticity of the undeveloped neuronic tracts is the great feature of the juvenile brain. A brain, which is healthily nourished and exercised, keeps young and plastic, and is one that gives its owner greater values in life.

Intellectual Actions.—It is difficult to analyse actions in such a way that the intellectual judgments of the supra-granular layer can be distinguished from the action of conditioned reflexes. Head, whose unceasing industry has unravelled many processes in the nervous system, found, in those with serious brain injury, conditioned actions which were so purposeful and varied in the response that it was difficult to believe the movements were not controlled by the will, although the patient might be quite ignorant of such movements. Nevertheless, the personality of an individual is the whole integration of existing circumstances that he is aware of, with the memories of all the past, so far as these modify and control

his instinctive reactions, and the real aim of education is so to build up his reflexes, and his memories, that instinctive reactions can be brought under control, to conform with the purposes of the individual in relation to the community of which he is a part.

It is notorious in daily life how underaction of the cortex, from want of development, effects of alcohol, or senility, may be regarded only as a little stupidity, a want of interest or wandering attention, owing to the fact that the individual carries on in an automatic way.

Twenty years ago, Head studied the peripheral nerves by cutting his own left ulnar nerve and following its repair. He deduced two sets of nerve fibrils, one dealt with elements of sensation, was vague in localization, with responses in movement of a generalized nature, which tended to withdraw the part from contact with the source of irritation. These he called protopathic nerves. The other system, exact and definite in sensations, enabled clear judgments and comparisons to be made. This he called epicritic.

The first protopathic set supply the material for action and execute the performance of the ancient brain (optic thalamus, corpus striatum). These sets come into knowledge only as obscure states, affecting the general feelings. They correspond to performances that are connected with the movements for withdrawing from, or escaping the consequences of, the particular stimulus. It is a purely instinctive and unintellectual animal reaction, and probably is the only form of nervous function existing at birth.

The other set of epicritic nerves furnish the material for judgments and associations in the cortex. They are the material out of which the main part of the intellectual life is built. Anything that suppresses or inhibits this higher nervous action is likely to allow the ancient parts of the brain to come into control. This dual nervous control seems to run all through mental action. The suppression of the higher control means regression to a lower mental, more animal and more infantile state. It tends to cause the individual to lean on others, acting reflexly, instead of facing difficulties. An observer can scarcely distinguish between a conditioned reflex and a voluntary action; there is a broad zone on which sometimes the action is a mere reflex, and sometimes voluntary.

Suggestion and Imitation.—It is likely that the infant or very young child has a transient acuteness of automatic appreciation of conduct in those around him as affecting himself; an intuitive appreciation of emotional conditions by which gestures and movements are interpreted on what may be called an animal plane. This is suggestion, the means of communication before speech was evolved. It belongs to the ancient brain, like the intelligence of the dog or of the calculating horses of Cologne.

Like many of these ancient functions, it too is soon replaced in great measure by the intellectual judgments of the slowly developing supra-granular cortex. The old machinery, however, still remains for the useful and instinctive orientation of life. These instinctive powers seem more vivid in the very young.

Once nervous action rises above mere instinct or the conditioned reflex, and two possible associations are presented, one of which has to be adopted and the other rejected, the conflict which constitutes discriminative mental life has started. The wish for the attainment of an end arises ; adjustments and arrangements have to be made to carry on the necessary movements or thoughts which represent the desires to be gained. It is to avoid unnecessary conflicts in the young child that a single aim, free from conflicting ideas or contests between different authorities, e.g. father and mother, at home and school, is so desirable. The wish is a complicated emotion with a far-reaching past, although it seems to be a terminus ; the unit from which students of the mind start, as well as the end to which their studies sometimes reach back. It is influenced or rather is the result (*a*) of the innate make-up or pattern on which the nervous system is built, (*b*) of the already acquired store of memories the result of life's experience, and (*c*) of suggestions arising at the moment. In the young child the first and last would be expected to preponderate ; whilst the first is beyond our control, the last is to some extent in our hands.

Suggestion is the most powerful factor in education. In the young it overrides all other factors. The child largely accepts what it is told, without much effort at judgments. At puberty the full critical faculty becomes established ; suggestion then becomes less acceptable. Suggestion, like faith, is not a matter of truth or intellectual judgment. It is largely the sensory homologue of the motor performances passing by the old motor path referred to on page 317. The suggestion is received by the instinctive or automatic sensory mechanisms and stowed away among emotional associations with their powerful springs of action. Its influence is mainly a matter of intensity and duration. Above all its chance of access depends on the suggestion being received at the emotional moment, when the attentive control of the supra-granular cortex is diverted. Indeed, if voluntary attention is directed to the suggestions, it is quite likely that not only will they be resisted, but contrary effects will arise by autosuggestion. This is what the modern Nancy school of psychotherapy calls the Law of Reversed Effects. Questioning children will bring out replies tending to agree with the questioner's ideas. If skilful, a cross-examiner can make a child witness, especially if feeble-minded, give evidence in almost any direction he wishes.

Imitation is an instinctive performance, almost a reflex at

early ages. It fades to some extent with intellectual development. It persists, however, at the root of the herd-instinct on which civilization has constructed its laws and conventions. Imitation is also one of Nature's powerful means in educating the young child. Its action depends on comparatively simple neuronic arcs, judging from its prominence in some animals; and in the early stage of the child, with its echolalia before speech. Imitation also may be persistent in some classes of the feeble-minded, as, for instance, the so-called mongols, where it is often prominent.

Imitation may be regarded as an automatic self-expression called out by suggestion. There are many forms of such expression in imitative, dramatic, rhythmic, musical, graphical ways; also in certain faculties such as dancing, chess play, acquirement of languages, symbolic or arithmetical reckonings, all of which seem largely akin to imitative automatisms. They are useful, but much lower than the intellectual levels, although used by them. They depend on mechanisms of nervous arcs, which act according to the perfection of structure with which the individual happens to have been endowed. If judged by other performances or conduct of these gifted ones, their gift is not necessarily any guarantee of the possession of the intellectual capacity or judgment depending on a highly developed supra-granular cortex.

It seems possible by certain devices, such as hypnotism, suggestion, and in other ways, to put whole regions of the supra-granular cortex out of action, or inhibit them, so far as consciousness is concerned. When this is done forgotten memories may emerge from the subconscious realms, and come into light. How or why this happens is a complete mystery. In some nervous conditions, such as are present in the hysterically disposed, or when under emotional stresses, as, for instance, religious ecstasy, or even through mere malnutrition from starvation, attention is diverted from realities, this inhibition of the highest control may occur spontaneously. Serious physical results are sometimes a later accompaniment, such as paralysis, pain, or other disorder.

The origin of these disorders, as Janet, one of Charcot's pupils, demonstrated, may be taken as being a previous psychical trauma, a fierce conflict that has remained unsettled by appropriate actions. Such a conflict becomes suppressed by the sufferer. Often the hidden trouble may be reached by a few questions, while at other times, when from experience the nature of the trouble is suspected, expression may be elicited by the method of surprise. Still, it must not be overlooked that the conflict can also be buried in the subconscious and quite unrealized by the patient until a question or memory makes its significance evident, so that the subject recalls facts or details connected or linked up with the buried experience.

Where an investigator has opportunities and can certainly

diagnose these functional conditions, with sufficient assurance or perhaps sufficient ignorance, to impress his patient, he sees quite frequently modern miracles occur, in that in a minute or two the blind may see, or the paralysed arise and walk. Other observers achieve results by patient and long-repeated suggestions. But in some cases the hoped-for result is not reached by these means. It was to reach these last cases that Freud, of Vienna, developed his technique of psycho-analysis, that he might search for the psychical trauma. Used first in the treatment of the class of hysterics, he afterwards applied it as a general method of research into the origin of mental actions. Assuming as self-evident that each thought coming into action has a definite cause behind it and a purpose, he attempted to follow back the tangle of clues to the start. Probably this is the greatest theoretical advance made in psychology for thousands of years. Freud narrowly missed being the Darwin of the mental world. His discovery has been so overlaid with an enormous stratum of pseudo-science that its full value is more likely to be depreciated than realized at present.

Neglecting the palpable absurdities, as well as a body of learning that recalls the wordy style and metaphysical scholasticism of the angelic doctors, the main results attained from psycho-analysis and appearing useful for our purpose are : (1) that it is possible to get glimpses of past psychic events, layer by layer as it were ; and (2) that every thought is the result of some kind of wish. These wishes can be classified ; in the end they lead back to one or both of the two great springs of action, self-preservation and race-preservation ; the ego instincts or the sex instincts.

A great part of the results of application of professional psycho-analytic theories may be artificially produced results of suggestion, but the ingenuity which has been applied in analysis has brought out much valuable study of the individual. In particular, what was only foreshadowed has now been made clear. It is realized that the young child is in a way the victim of its surroundings ; unconsciously registering the sights and sounds of its environment, so that later these become the foundations of its emotional and intellectual experience.

Disturbing Elements in Mentality.—Self-preservation, to take one simple example, is an instinct which makes the infant carry everything to its mouth. This instinct has its protective measures in pain and fear. Fear, one of the fundamental mechanisms of protection, is also one of the most powerful emotions to which all are subject, except in the extreme risk of life, when even fear may be inhibited by mechanisms, which make the drowning man suddenly become calm and apparently indifferent, so that he can put forth his last and often successful efforts.

Fear will be found at the base of many childish troubles, such,

for instance, as stammering, and many particular as well as general forms of nervousness. The child's whole future is conditioned and biased by its reaction to fear in its earliest days in its home. Half of the nervous children are products of single-child homes, suffering fears suggested by anxious parents. Suggested fears are powerful enough to go no further back. One need not join the credulous here, who talk pre-natal psychology, or hope to recover experiences of ascidian days, to understand the psychology of the puppy which tears up whatever it can get from the baby's basket. The same stage of mentality affects the baby itself when first its intelligence appreciates mother or nurse, and it finds a rival.

These emotions and nursery conditions may predetermine a child's future mental bias. At a comparatively early age the child seeks to assert itself, and gain approval and attention. In the case of many children the conflicts that arise out of these continuous struggles for self-assertion result in the development of a mass of memories and inhibitions, which, remaining concentrated about the central stimulus, form the so-called complex. Such a complex, with its painful associations is soon suppressed, sunk in the unconscious, and although for a time it may influence thought and action it is usually forgotten, and probably in healthy individuals slowly disappears. In others it remains dynamic, to crop out under circumstances of stress and strain, or indeed to present itself subconsciously in the guise of various enduring nervous actions. As a rule the complex, if it produces action, does so to the owner's disadvantage. It is a tendency or drive which is out of harmony with the rest of the life course, and is erratic, twisting things in accord with the old conflict which was excluded and therefore suppressed, but now revives for a time.

Obviously there are many conflicts which may arise in normal family life. They soon group themselves in one's mind, especially when numbers of either teachers or children with nervous troubles are seen. It is scarcely ever realized how limited is the field of thoughts, beyond concrete things and actions, in the pre-adolescent child. Abstract nouns are not properly understood at the primary school age. The American Committee on Health Teaching point out that children of 8 do not know what health means beyond "It is when you drink milk," "It is if you brush your teeth," and so on. Morality in the ordinary meaning of the term is scarcely sensed by the pre-school child. It is under the control of its instincts. The teacher who tells the eight-year-old, before punishing him, that "This hurts me as much as it hurts you," is regarded by the child, if he thinks of it at all, as a hypocrite or a liar. The ordinary school child obeys the personal authority of those in control, but the idea of law as something to which to conform one's life is an abstraction scarcely attained before puberty. Pre-

adolescent ability to generalize is equally limited. Children do not interpret *Æsop's Fables* before 12 years old, and Shakespeare in the primary school is likely to be more educative to the teacher than to the taught. It is then when abstractions and generalizations begin to be realized fully, when a scheme of life is being developed individually, that any dynamic influences of past complexes begin also to be realized. These take their share in the character development, but in the unstable this share may mean abnormality, either in conduct or changes of capacity.

Adolescence, and the difficulties of adaptation, which are especially common in our secondary schools to-day, frequently bring out strange nervous conduct in girls. Almost without exception, when not due to actual disease, it will be found that these girls come from homes where matrimonial troubles are found to have prevailed a dozen or more years ago. Just as an upset physically, an attack of indigestion for example, may arrest a young child's growth for weeks, so a mental upset may arrest development in a lower mental stage, and a complex may form which inhibits one part of the child's mentality. The individual suffers a fixation of interests at a comparatively juvenile or infantile stage. These matters will have to be slowly worked out by teachers and doctors in the nursery school.

Natural Education in Nursery Age.—It can do nothing but good to the young child, in regard to its future life as a citizen, to have it mix with others on its own mental plane, as soon as it leaves its mother's apron-strings. Hence the advantage of nursery schools. Companions of the child's own age suggest simple activities and ideas, which are required to develop and bring out untried capacities, that is, to give the child physiological education. The purpose of education is to form good working habits. It is the business of the brain to be labile and unstable. In the infant where mentality is not fixed by habit as it is in the adult, all kinds of slight variations easily occur ; they cause attention to be directed to itself. Living at home all day long, particularly a first or only child with an anxious mother, its interests are unwholesomely concentrated. Suggestions of its self-importance are too strong and too constant. Interest in all its functions are aroused, and once attention is turned to these mechanisms, trouble is likely to arise. In certain children whom we term neurotic or nervous there seems to be a feebleness of the sympathetic nervous system, so that visceral control instead of going on automatically shews many aberrations. The most common of these is a want of tone in the postural muscles ; the child is slack in its attitudes. It is likely to have a bent back, flexed joints, and protuberant abdomen, leading to attitudes of fatigue, and a want of tone in the blood-vessels ; flushings and congestions also result ; all of which react on the nutritive functions,

particularly on respiration and the circulation. The thermometer, too, may easily run up with many of these children.

Some children seem to feel a sense of power in the annoyance or worrying of their relatives; the sign or symptom that has elicited this expression may then be used as a kind of weapon by which the child gets its own way. Tempers or vomiting, or declining food, negativism in refusing to do what is wanted or suggested, are all forms of conduct, cultivated by the unwholesome atmosphere of anxious attention at home.

Dr. Watson, in the West Riding, gives an illustrative case of a girl who could not sleep. "The mother said that as an infant the child slept only about twenty minutes at a time, for a year she had slept with the child in her arms. At present the little girl sleeps in a cot by the bedside and frequently is taken in beside the mother. The father is away on night-duty. The mother spends her whole day and night looking after the child; until recently, when fortunately the child started attending school, she has been in the habit of not allowing the child out of her sight."

Wholesome neglect plays a great part in the cure of such children, and in the skilled nursing of a children's hospital where this is properly applied, it often works wonders in regulating the behaviour of the most turbulent or spoiled infant even in a few hours.

There is always danger of the formation of the so-called mother-complex, by unceasing anxiety and obvious attention on the mother's part. In the baby-room attention should be turned, not on the child's feelings or appearance, but on its acts and deeds; what it can do, and not how or why it does it, is the chief aim. There is excessive teaching in what it must not do. The formation of conditioned reflexes by inhibitions of this kind means a great deal of repression, whilst expression is what really is wanted. The nervous child has its higher control repressed so that emotions are apt to become too prominent in the control of conduct. Expression makes for health, repression for the contrary. It means that in later life the individual may have many of his talents hidden in a napkin, until some mental upheaval arises. It is this class of repressed individual whose troubles the honest psycho-analyst may properly help.

Cases can be recalled typical of the effects of such repression. One, a brilliant girl never away from her mother's apron-strings till she went to one of the old Universities, and then had to go down owing to a nervous collapse and incapacity for any work. This was apparently due to separation from home.

Another case, a young woman, who after several years of school teaching left home in order to go to Canada, continuous illness, nervous gastritis, and inability to keep at work, resulted in her having to return to her mother.

These cases can hardly be called mentally abnormal. They are examples of hundreds of cases. Usually they are clever and able in school work; until through some unexpected situation they find themselves unable to work efficiently; but they are in no sense defective. Improper mental hygiene in the home has given them a wrong start. As young children, they come into school shy or fearful and timorous, sensitive, indolent, or day dreaming. Without much contact with other children, they have been sheltered or repressed until unable to adapt themselves. School should help them, or later they will become socially inefficient, if not delinquent. The silent arranging type classed as introvert is common in contradistinction to the mental type of triers and doers—the extraverts. A mother can become in a way a vampire mother, seeking the affections of her child so constantly that she almost deprives it of the power of affection for others in later life. Association with its physical and mental equals is the best education and the hygiene for such a child. The nursery school should be the cure for this early ruining from over-attention in the home. It is unfortunate that such schools are not being encouraged. This is due to ignorance of the administrative authorities, to whom education generally connotes literary subjects. Even at the nursery school age there may be exceptional cases requiring special treatment, and later the number of such cases will have considerably increased.

The town child getting comparatively little physical exercise, and seeing constant changes around it, is usually irritable, easily exhausted, and superficial in judgment. It not only wants exercise, but also rest. It is often debilitated. The weakened stomach has not the cry for food of the boy or girl who lives and plays in the country. Many of these town-bred children develop a habit of no breakfast, or even of vomiting what they take ere they come to school in the morning. I have never been able completely to account for these symptoms, whether it is due to bad mental or bad physical hygiene; both are usually present. It is a common condition; moreover, it is curable by the open-air school treatment of exercise, feeding, and rest.

Habits.—Laziness so common among many children is probably a habit having some physical cause, of which inability to maintain attention seems to be the outcome. It requires a careful exploration, as a nervous symptom which should be amenable to proper school hygiene. It may even be a protective mechanism.

The habit clinics, which have originated in America, are psychological clinics which utilize the best time in the child's formative stage for the investigations of educationally inefficient, mentally abnormal, or older delinquent children. This is work begun at the right end of educational life, for habits are more easily altered at 5 than at 15.

Dr. D. A. Thom (U.S.A. Labour Bureau, Pub. 135, 1924, *Habit Clinics*) shews how family relationships of these children must be considered. Mother, father, or another child in the family is almost always connected with the trouble and has also to be regarded as well as the patient.

Social relations have to be investigated sympathetically by a school nurse ; the inherent mental endowment has to be assessed psychologically, as well as the actual behaviour of the child in school ; all the many contributing causes have to be gone into, and many faults of adjustment straightened out. Only experience and sympathy can prevent such interference in family relationships complicating matters, and unless placed in properly qualified hands any enquiries of this kind may easily become mere quackery. The treatment of these children must at all costs be kept free from intrusion of the voluntary worker, or the catastrophe of unsympathetic C.O.S. ideals. Thom, in a later publication (*Child Management*, Labour Bureau, No. 143, 1925), shews how habits must be made for many children by direction of emotions and activities.

The Healthy Personality.—The Joint Committee on Health Education in the United States (1924) has described the emotional, mental, moral, and social qualities of a healthy personality so well, shewing how it is balanced without suppressing individuality or conforming to a uniform pattern, that we cannot do better than take their description.

1. The child possesses intelligence adequate to meet the demands of his life. This includes the whole range of intelligence from very superior to somewhat below the average. Some very healthy personalities are found among those whose intelligence is inferior to the average, but is nevertheless sufficient to meet the demands of their simple lives of manual work.

2. He is able to concentrate his attention upon the matter before him and to perceive the important elements of the situation with accuracy and alertness.

3. He is interested in the world about him and curious to understand it.

4. He is generally self-confident ; he expects successes and achieves them with a reasonable frequency.

5. He is active in overcoming difficulties ; he does not "day-dream" so much that he fails to meet the actual situation.

6. His predominating emotional qualities are happiness, cheerfulness, courageousness. He is not troubled by unnecessary fears, shyness, or timidity. His emotional responses are those that are appropriate and useful for the occasion.

7. He does not ordinarily brood or sulk or indulge in morbid introspection.

8. He has many objective interests ; friends, hobbies, games in which he finds adequate self-expression.

9. He is companionable and mingles easily with other children. He adapts himself easily to co-operative enterprises ; to leadership or followership.

10. The child's relationship with children of the opposite sex are wholesome.

11. He has a sense of responsibility for the happiness and well-being of his friends, schoolmates, and members of his family.

Intelligence is one thing, morality another, and wisdom combines them both in a sound mentality. There is yet much that is too vague to generalize about here ; much, too, that in the future will have important educational bearings, and in some cases will be again referred to in connection with speech, dexterity, morality, and other topics.

CHAPTER XIX

INTELLIGENCE

Intelligence is the capacity of adaptation to the various conditions of the environment, and of accomplishing purposes beyond mere instinctive actions.

Apart from early domestic or family suggestions and what may be called misfits, arising out of the false orientation they may cause, the individual's position as a unit of the social structure depends on intelligent response in adaptation to his surroundings. For those exhibiting defects in this regard no provision was made in the earlier days of popular education. A generation had passed after Forster's great Education Act of 1870, ere the permissive Elementary Education (Defective and Epileptic) Act, 1899. Half a dozen years before this London, Leicester, Nottingham, and Bradford had acted for themselves in providing for such defective pupils, as they had, what were called "Special Classes."

The difficulty at that time was a better diagnosis than trial and error of school failure. The practical purpose was to select children unfit for ordinary schooling. Having to find the way at first, attention was paid to physical appearances suggesting irregular development. Defects of the senses were sought, "spurious mental defectives" were found ill-nourished, or blocked with adenoids. Warner's stigmata of defect were given some weight. The attempt to determine mentality depended very much on age of the child and school reports.

For his own satisfaction the examiner empirically tried an elementary set of questions to settle unfitness. What is your name? Where do you live? How old are you? How many fingers have you? If you had twice as many, how many would that be? What is a cat (or horse)? What day is it? What is the day after to-morrow? These questions will still be sufficient rapidly to detect 90 per cent. of the children whose level of intelligence renders them mentally unfit for ordinary school education. The report often took such a form as "Poorly nourished, is nine years old, looks seven, and answers like five." Assessment by developmental stage of conduct is important. But some cases were unsatisfactory, and some schools had large Standard 0 classes. It was doubtful whether many of these children were not merely

suffering from protein starvation, or whether they were "motor-minded," active in games, hopeless with books. Considerable numbers, at least 10 per cent., were found falling behind and unable to appreciate reading and writing properly, but yet not strictly mentally defective. But even such crude sensory conditions as the refractive condition of the eyes, the presence or absence of spasm of the accommodation, or retinal disease must be definitely excluded. Further, hardness of hearing accounts for a large proportion who give poor returns, so that no scale, however perfect, is of much value if medical examination is not thorough. Behaviour at the examination, such as boldness, unabashed conduct, or want of proper respect, and undue smiling or shyness were all allowed weight in a crude way. Indeed, "the smiler" was often regarded as almost an inattentive imbecile. Mistakes were made. On first going over the books of a class to assess rough results, an enquiry for a boy reported as dismissed four years before, with the only note "Imbecile, unfit for further school," elicited the remark, "He is running two shops in Whitechapel now." Evidently something better was needed for diagnosis and prognosis.

By the time this slender technique had been arrived at, Binet and Simon in Paris produced their famous scale for the assessment of intelligence. They endeavoured by a set of test questions submitted to each child to ascertain its level of intelligence, compared with the average level of intelligence of children at different ages, in the common environment of the French school child. Their scale extended from 3 to 12 years of age, and was intended to exclude adventitious schooling, and merely test "mother wit" or capacity for acquiring and applying useful knowledge of life. The determination of such a scale must be a matter of experimental observation, and arrived at statistically by trial and error.

Their questions involved simple mental actions not requiring scholastic information, but merely knowledge that an individual should acquire from experience of life. This actual living experience should teach how the application of knowledge derived from one set of circumstances can be used for another set of somewhat similar cases. But testing this means testing the individual's power of adapting himself to his environment, which is the whole purpose and function of the nervous system and of intelligence. The B.S. Scale was first published in England in my own translation from the fourteenth volume of *L'Année Psychologique*, by *School Hygiene* in 1910. 102. Although much worked upon since then, the principle has undergone no serious change. Intelligence assessment was at once enormously simplified, and the method was seen to be almost an inspiration for practical purposes. Goddard early adapted it at Vineland for American use. Terman after several years' work, improved, polished, and extended it for American

children aged from 3 to 16.—the Stanford scale—and by using six tests for each mental age-level, each question answered apparently corresponds to a mental age of two months. This detailed exactitude may have laboratory advantages, but for the medical officer it has no advantages over the B.S. Scale, and indeed has the disadvantage that it is more costly in time. Terman's revised scale is now generally used in America.

Burt, finding London children a trifle precocious compared with others, has also contributed suggestions. Yerkes, by altering the marking, has formulated what he terms a point scale for intelligence. The writer deems this point scale simply a convenient short statement, but the points are in no sense units, and differences of points do not indicate so many quanta of intelligence. Unless this is borne in mind the point scale tends to give an illusory sense of exactness.

Intelligence Tests.—The attempts at refinement, gradation of marking, and the punctilio in details of method for applying the test seem at times heavily discounted by the environment, temporary emotional condition of examinee, and personal equation of the examiner; and the refinement of ages down to months is rather suspicious of a numerical accuracy giving spurious results, especially if one remembers that in the sixty-five tests only four, according to Burt, are assigned to the same age group by all the investigators.

For purposes of the medical examiner a mental age to six months will be near enough. The forms of question should never be varied, and an even and unemotional tone of voice used in propounding them. Always ask the question gently, do not give orders. This is especially important at the suggestible younger ages. There should be nothing distracting about the examination, and the examinee should have no period of sustained expectation, in which to develop fears or doubts, before being sent for examination. The examiner's first duty is to establish a sympathetic confidential interested attitude, so that the child is *en rapport* with the work before it. Williams and Boome suggest a preliminary test, in which speech is not needed, to gain the child's confidence. It is useful in the case of the nervous child who sometimes at first gets a kind of stage fright. They use a cardboard with sunken circular spaces coloured red, green, blue, and yellow, and have some coloured discs to fit. They shew this and fit them in, then they are removed, and signs made to the child, or it is asked to also fit them properly. A three-year-old does it, and almost any child thus is given a fair start for later testing (*L.C.C. M.O.*, 1923. 104). There must be no criticism of individual results, or educative efforts; the tests are merely submitted in a way that the child should understand, and a casual word or two of encouragement rarely thrown in here and there. The child either passes or fails in each test.

The story must be remembered of the small boy who, after being noted as "quite unresponsive" to absurdities, confided outside, "I say, nurse, the lady doctor in that there room is balmy."

The following schedule of tests, using Burt's numbering, may be given merely for reference in ordinary testing, but no attempt has been made to set out precautions for exact psychological laboratory work as it is quite impossible to gain familiarity with this work except by real practical experience. After each test the Stanford Revision value is given, i.e. S.R. IV, and where the test is altered *a* added.

The writer cannot agree for a moment with the high pretensions of some psychologists that years of training are necessary. Any intelligent teacher with careful reading and understanding of the tests, after using them for a few weeks should get as accurate results for practical purposes as the average psychologist. Under each age as central age is stated the various tests, about half of these should be done by children in the previous half-year; for instance, there are six tests to be done by children of 8 years old last birthday, half of these should be managed by a child aged 7½ to 8. The following convention about ages has universal adoption. The age as determined by the performances of tests normal for that age is noted in Roman numerals VII, X, etc., and called the Mental Age. The chronological age is always stated in Arabic figures, 1, 2, 3.

The most useful method of scoring is Goddard's. He takes the basal year in which all the tests are completely done, then adds a year for every five tests done beyond that. Unless a child or group of children differs from stated averages by one year at the very least little significance can be attached to the divergence.

Age III.

1. *Understanding Simple Commands.*

"Show me your nose, eyes, mouth." All three requests should be complied with after, if necessary, several repetitions. (S.R. III)

2. *Repeating Two Numbers.*

"I am going to say some numbers, say them after me." One correct of three trials is success. (S.R. III)

3. *Naming Own Sex.*

"Are you a little $\begin{cases}\text{boy}\\\text{girl}\end{cases}$, or a little $\begin{cases}\text{girl}\\\text{boy}\end{cases}$?" Simon suggests that this should be put as a single question, naming the sex of the child in the first part. (S.R. III)

4. *Giving Surname.*

"What is your name?" If the surname (father, mother) can be elicited by other questions, it passes. (S.R. III)

5. *Naming Simple Objects.*

A simple object shown, such as penny, watch, knife, key, pencil. Three to be named. (S.R. III)

6. *Describing Pictures.*

Several simple pictures may be shown and the responses noted whether persons, objects, or details are given. At this age it can hardly be called "describing," the child enumerates one or two things which it recognizes. (S.R. III)

AGE IV.

7. *Repeating Six Syllables.*

"Listen and say this after me." Repeat a sentence of 2, 4, 6, 8 syllables, and the number noted which the child repeats correctly. No error is to be allowed. (S.R. III)

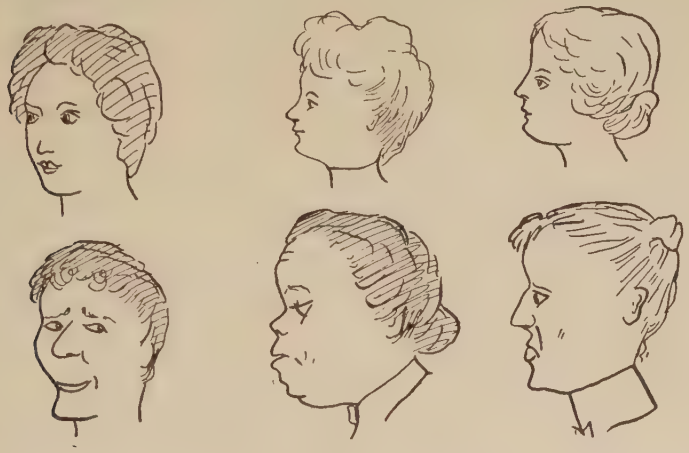


FIG. 67.—BINET'S "FACES."

8. *Repeating Three Numbers.*

"Listen and say these numbers after me." "914" (286, 539). One correct repetition out of three allowed, passes. (S.R. III)

9. *Counting Pennies.*

Four pennies. "Do you see those pennies, tell me how many." Two attempts may be allowed, as the first answer may be at random. (S.R. IV)

10. *Comparing Two Lines.*

Two parallel lines, 5–6 cm. long, with centres below each other and about 3 cm. apart, are shown drawn on a card. "Do you see these lines? Which is the longer?" There should be no hesitation. (S.R. IV)

11. *Comparing Faces.*

Faces shown two at a time, one ugly, one pleasant. "Which is the pretty one?" Three pairs used. (S.R. V)

AGE V.

12. *Performing a Triple Order.*

Having placed a key and book in position before interviewing the child. "Do you see this key. Go and put it on the table, then shut the door. After that bring me the book that is on the chair beside the door. Do you understand? First put the key on the table, then shut the door, then bring me the book." All three should be at once performed without further instruction.

The form of this question used in London was, "Put on your hat. Take a pencil from the table and put it on the form outside. Come back and mind to shut the door after you." Most failed to do more than two commands. The usual result was for the child to put on his hat, go outside, and then have to be fetched back. (S.R. V)

13. *Drawing a Square from a Copy.*

A square of 3 or 4 cm., side-drawn on a card, shewn. "Copy this for me. Draw it here." Hand pencil and paper, note left-handedness. One attempt is enough. (S.R. IV)

14. *Repeating Ten Syllables.*

"His name is Jack; he's such a naughty dog." (S.R. IV*a*)

15. *Giving Age.*

"How old are you?" Should give age in years. If first answer is doubtful, ask: "How old were you last birthday?" (S.R. V)

16. *Distinguishing Morning and Afternoon.*

"Is it morning or afternoon now?" Mention the one which it is first. (S.R. VI)

17. *Naming Four Primary Colours.*

Four slips of bright red, yellow, blue and green, 2 × 4 cm., are pasted on a card parallel with 2 cm. intervals between them. "What colour is this?" point to each in turn. No error allowed. (S.R. V)

18. *Repeating Four Numbers.*

"3681, 5749, 8526." One correct out of three trials allowed. (S.R. IV)

19. *Comparing Two Weights.*

Four pill-boxes, similar in colour, material, and size are weighted to 3, 6, 12 and 15 grammes. Two are placed, one in each hand. "Which is the heavier?" Two other pairs are tried. All should be correct. (S.R. V)

AGE VI.

20. *Giving Number of Fingers.*

"How many fingers have you on your right hand; and how many on your left hand? How many is that on both hands together?" All three should be correctly answered without stopping to count. (S.R. VII)

21. *Counting Thirteen Pennies.*

These are placed haphazard. (S.R. VI)

22. *Drawing a Diamond from Copy.*

A diamond or rhombus, about 4 cm. edges and 7 cm. high, is shown drawn on a card. "Copy this for me." Giving pencil and paper. A recognizable shape is accepted. (S.R. VII)

23. *Transcription.*

A sentence of three simple words with two capital letters copied legibly. (S.R. omits)

24. *Naming Days of Week.*

"What are the days of the week?" Should be reeled off at once, or fails. (S.V. VII)

25. *Naming Four Common Coins.*

½d., 1d., 6d., 1s. are placed on table indiscriminately, and all four named correctly, one by one. (S.R. VI)

26. *Reconstructing Divided Oblong Card (Patience.)*

A visiting card, white on one side, blacked on the other, is cut along the diagonal. The pieces thrown down with the two short sides nearly vertical to each other. Another card is shewn. "One of my cards has been cut in two; can you put the pieces together again to make a whole one like this?" (S.R. V)

27. *Defining Concrete Terms.*

"What is a horse, chair, mother, school, soldier, table, doll, baby, fork, spoon, pencil?" Three out of five to be correctly stated. (S.R. V)

28. *Repeating Five Numbers.*

"52947, 63852, 97318." One correct out of three trials. (S.R. VII)

29. *Describing Pictures.*

Terms should be used describing actions and characteristics. (S.R. VII)

30. *Repeating Sixteen Syllables.*

Repeat after me: "We are going for a walk; will you give me that pretty bonnet?" (S.R. VI)

31. *Distinguishing Right and Left.*

"Shew me your hand. Shew me your left ear." Eye, or leg, may be used. To be done without hesitation. (S.R. VI)

AGE VII.

32. *Recognizing Missing Features (Mutilated Pictures.)*

Four pictures (Binet) shewn, without mouth, nose, eye, and body without arms. "Look at this man's face, can you tell me what has been left out? What has been left out here?" Three correct out of the four pictures for a pass. (S.R. VI)

33. *Adding Three Pennies and Three Halfpennies Mixed.*

"Count this money for me, and tell me how much there is." No error and no repetition allowed. Americans usually substitute postage stamps for the coins here, as they do not have the values in coins. (S.R. IX*a*)

34. *Stating Differences between Concrete Objects.*

"You know what a butterfly is ?—And you know what a fly is ?—They are not the same ?—In what way are they not the same ?—Can you tell me the difference ? "

(i) Fly—butterfly. (ii) Wood—glass. (iii) Paper—cardboard. (iv) Milk—water. (v) Apple—banana. (vi) Paper—cloth.

Two out of three should have a correct difference stated. (S.R. VII)

35. *Writing from Dictation.*

"Will you write this down for me ? 'The pretty little girls.' " This should be so well done as to be legible. (S.R. VIII)

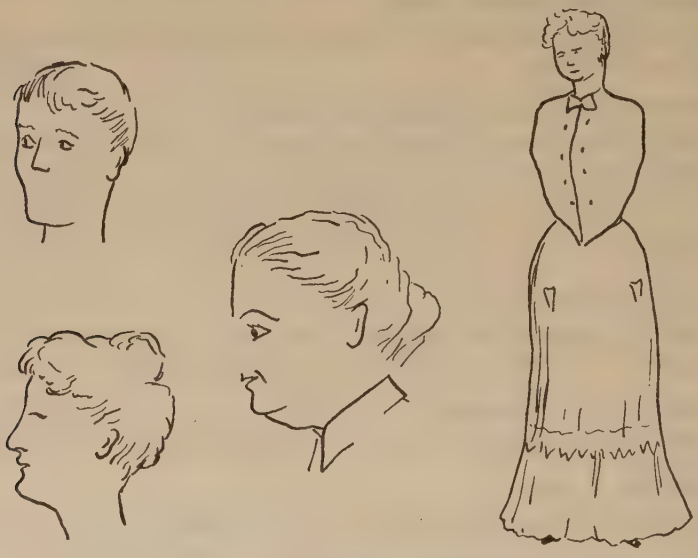


FIG. 68.—BINET'S "MISSING FEATURES" TEST.

AGE VIII.

36. *Reading and Reproduction.*

"Will you read this for me ?

"'THREE HOUSES ON FIRE.

"'LONDON, *September 5th.*

"'A big fire last night burnt down or destroyed three houses in the middle of the city. Seventeen families now have no homes. The loss is more than 150,000 pounds. A young barber, who saved a baby in its cradle, was badly burnt about the hands.' "

The child should read this, and asked, two seconds after finishing, should recall at least two items, at age VIII (and six items at age IX).

(S.R. omits)

37. *Answering Easy Questions (Comprehension).*

"Tell me this. (i) If you have to go somewhere by train, what must you do if you miss the train ? (ii) What ought you to do if you broke something that belonged to somebody else ? (iii) If any of the other boys

(girls) hit you by accident, without meaning to, what should you do then ?" If the child utterly fails on the first, omit the rest. Two of the three should be satisfactory. (S.R. VIII)

38. *Counting Backwards*, 20—1.

"You can count, can't you ? 1, 2, 3, and so on. Now, do you think you could count backwards ? Start at 20 and count backwards to 1." One mistake allowed. (S.R. VIII)

39. *Giving Full Date.*

"What is the date to-day ? What day of the week is it ? What month ? What number of the month ? What year ?" All four should be given correctly, but an error three days either way in day of month allowed. (S.R. IX)

40. *Giving Change.*

Some of the commoner coins. ¼d., ½d., 1d., 6d., 2s., 2s. 6d. = 10s., and in addition three pennies and three halfpennies. "Now shall we play at shop for a change ? You shall be the shopkeeper. Here are some boxes for you to sell, and here is your cash. Will you sell me one of your boxes ? How much are they each ? Twopence, shall we say ? Well, here is the money. Can you give me the right change, please ?" The child must hand over the correct change. (S.R. IX)

41. *Repeating Six Numbers.*

"250364, 853916, 471582." One correct out of three trials. (S.R. X*a*)

AGE IX.

42. *Naming Months.*

"Can you tell me the months of the year ?" One error allowed. (S.R. IX)

43. *Naming Nine Common Coins.*

Nine coins in a row, heads uppermost, should be named. The florin and half-crown easily confused. (S.R. VIII*a*)

44. (Burt) is superior reply to 36 and 45 (Burt) a superior 37.

AGE X.

46. *Arranging Five Weights in Order.*

Five weight boxes identical in form and colour, loaded to 3, 6, 9, 12 and 15 grammes. (Key letters B, I, N, E, T, may be used on bottom.) "Do you see these boxes ? They all look, but they don't weigh, the same. Some are heavy and some are light. Find the heaviest and put it here. Then find the one which is a little less heavy and place it next ; then the one which is still less heavy ; then the one which is lighter still ; and last, the one which is lightest here." They should be correct in two out of three trials. (S.R. IX)

47. *Sentence Building with Three Words.*

Pencil and paper is provided and a card is shewn with London, river, money printed on it. "Make up a sentence for me with these three words in it—London, river, money." Hand the card and repeat : "London, river, money. Write a sentence containing those three words." The card

need not necessarily be used nor pencil and paper. The sentence may express one or two separate ideas. Three ideas is a failure. (S. R. IX)

48. *Drawing Two Designs from Memory.*

The two designs in Binet's Fig. 69 are shewn for ten seconds. "There are two easy drawings on this card. I want you to look at them very carefully until I take them away, and then try if you can draw them both from memory, on this paper, afterwards. You will only see them for a few seconds. Now look at them both carefully first of all. Ready? Now." The whole of one and at least half the other should be done fairly. (S.R. X)

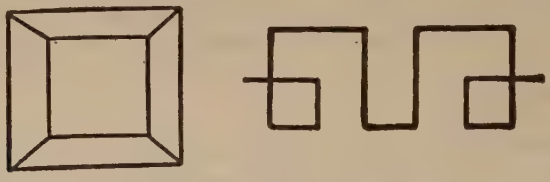


Fig. 69.—BINET'S "DESIGNS."

Age XI.

49. *Explaining Absurdities.*

"Listen carefully to what I am going to say. There is something in it which is really silly. See if you can tell me what is wrong.

(i) "One day, a man fell off his bicycle on to his head, and was killed instantly. He was taken to hospital, and they fear he may never get better.—What is there silly in that?

(ii) "I have three brothers—Jack, Tom, and myself.—What is silly in that?

(iii) "Yesterday there was a railway accident, but it was not a serious one. Only forty-eight people were killed.—What is silly in that?

(iv) "Once the body of a poor girl was found in a wood, cut into eighteen pieces. They say she killed herself.—What is silly in that?

(v) "A man once said: 'If I should grow desperate and kill myself, I shall not choose a Friday to do it on; for Friday is an unlucky day, and would bring me bad luck.'—What is foolish in what the man said?"

Three absurdities should be detected out of the five. (S.R. X)

50. *Answering Difficult Questions* (*Comprehension*).

"Can you tell me this?

(i) "What should you do if you found you were late on your way to school?

(ii) "If someone asked you what you thought of a boy (or girl) whom you did not know very well, what should you say?

(iii) "Suppose a boy does something that is unkind. Why do we forgive him more readily if he was angry than if he was not angry?

(iv) "Why should we judge a person by what he does, and not by what he says?

(v) "Suppose you were going to undertake something very important, what should you do first of all?"

Repeat a question in the same words, if necessary, and allow 20 seconds for answer. There should be three right of the five. (S.R. X)

51. *Giving 60 words in Three Minutes.*

"I want you to tell me as many words as you possibly can in three minutes. Some children can give more than 200. Keep saying words like this till I stop you: box, coat, tree, cart, and so on—any words you like. Are you ready? Now start." 60 words must be given, exclusive of repetition. If the child gives sentences, stop him, and begin again. The limit must be the three minutes, as by this means association time between words is measured. (S.R. X)

52. *Repeating Seven Numbers.*

"Say these numbers after me: 9684751, 4820365, 5928136."
(S.R. XIV*a*)

53. *Sentence Building with Three Words (Maselon's Test).*

London—river—money should be put into one idea or sentence.
(S.R. omits)

AGE XII.

54. *Giving Three Words to Rhyme.*

"Do you know what a rhyme is? When two words end with the same sound we call them rhymes. 'Jill' rhymes with 'hill' because they both end in 'ill.' Do you understand? Now can you give me three words which rhyme with 'obey'?" (S.R. IX*a*)

55. *Rearranging Mixed Sentence.*

"Put these words in order and find out the sentence which they make." Three cards are given with the words.

A defends master dog good bravely his	my asked paper the teacher I correct to	started the for morning early this We country

Two correct solutions should be given in a minute. (S.R. XII)

56. *Describing Pictures.*

The child mentions the situation or emotion the picture suggests.
(S. R. XII)

AGE XIII.

57. *Resisting Suggestion (may be omitted).*

A book of six leaves with two lines on each page, on the first three pages the right-hand line is always longer than the left and each pair longer than the last, in the next three pages the lines are equal. "Which is the longer of these two lines?" for the first three; and for the last, "and of these." The child passes if he judges two out of the last three pairs as equal. This test is now regarded as of trivial importance. (S.R. omits)

58. *Solving Circumstantial Problems* (*Problems of Fact*).

"Can you guess the answer to this riddle?

(i) "One day a woman walking in Epping Forest, stopped still, terribly frightened. Then she hurried to the nearest police-station and told the policeman she had just seen hanging from the branch of a tree a ——. What do you think it was she saw?

(ii) "My next-door neighbour has had three visitors. First, a doctor called; then a lawyer; and then a clergyman. What do you think has been happening there?" Both should be answered. (S.R. XIV)

AGE XIV.

59. *Repeating Twenty-six Syllables.*

"The other morning I saw in the street a tiny yellow dog. Little Maurice has spoilt his new apron." (S.R. omits)

60. *Defining Abstract Terms.*

"Can you tell me this? What is (i) kindness, (ii) justice, (iii) charity, (iv) health." Two out of three should be correct. (S.R. XII*a*)

AGE XV.

61. *Drawing from Imagination the Cuts in a Folded Paper.*

Two sheets of paper about 15 cm. square; a pencil; one sheet folded in four like a letter ready for an envelope, and re-opened. In the middle of the edge which presents but a single fold, a small triangular notch about 1 cm. deep is drawn. "Here is a sheet of paper, which I am going to fold." The examiner refolds the paper whilst the child watches. "Suppose now I cut out a notch here. When the paper is unfolded again what would it look like? Will you shew me on this piece of paper how, and where, it would be cut?" The examiner places the folded paper in front of the child with the corner showing the folds, and the pencil-mark uppermost. Two diamond-shaped holes should be drawn. (S.R. Superior Adult)

62. *Give Differences between Abstract Words.*

"What is the difference between (i) pleasure and happiness, (ii) poverty and misery, (iii) evolution and revolution?" Two out of three should be correct. (S.R. Adult)

63. *Drawing the Reversed Triangle.*

An oblong card 10 × 15 cm. cut diagonally is laid on the table with cut edges together. "Look carefully at the lower piece of this card. Suppose I turn it over and lay this edge (pointing along the lower edge AC) along this edge (the diagonal of the upper triangle), and suppose that this corner (pointing to C) is placed at this point (pointing to B), what would it all look like? Now I am going to take the piece away (removing lower triangle out of sight). Imagine it placed as I told you and draw its shape in the proper position. Begin by drawing the top triangle." ACB should be a right-angle, and AC shorter than AB (Fig. 70). (S.R. omits)

64. *Summarizing Hervieu's Reflections on Life.*

"Attend carefully to what I am going to read to you. I shall want you to tell me in your own words the meaning of what I read. Listen.

"'Many opinions have been given on the value of life. Some say it is good; others say it is bad. It would be truer to say it is just medium. For, on the one hand, the happiness it brings us is never so great as we should like; and on the other hand, the misfortunes it brings us are never so great as our enemies would want us to have. It is this mid-way quality that makes life fair; or, at least, prevents it from being altogether unfair.'

"Now give me the sense of what I have just read to you." The central thought must be understood, and the three ideas: (i) Life is neither good or bad. (ii) It is not so good as we wish. (iii) Better than what others wish. (S.R. Adult)

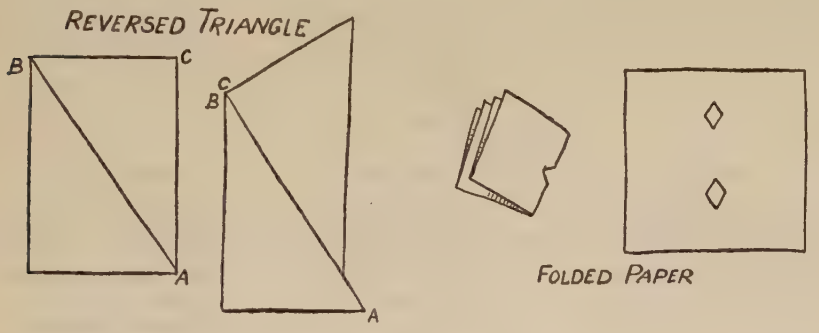


FIG. 70.—BINET TESTS FOR TESTS NO. 61 AND NO. 63.

65. *Giving Differences between President and King.*

"There are three chief differences between a President of a Republic and a King. Can you tell me what they are?" Two differences of the following. Inheritance. Duration. Powers. Responsibility. (S.R. XIV)

Dr. Lewis and Professor Burt have made an arrangement of these tests, as given below, for use in an extensive enquiry now being conducted. The years III, IV, V are as already given. From VI to XVI there are five tests for each year, and some alternative tests starred which may be used in substitution. The tests for XVIII are omitted.

YEAR VI.

1. Diamond.
2. Divided card.
3. Definition (use)
4. 5 numbers
5. Picture.

YEAR VI (ALTERNATIVE).

*6. 4 coins.
*7. 13 pennies.
*8. Transcription.
*9. Weekdays.
*10. Fingers.
*11. 16 syllables.

YEAR VII.

1. Missing features.
2. 3 pennies and 3 half-pennies.
3. Differences (concrete).
4. Tying bow knot.
5. 3 digits back.
*6. Days of week (check).
*7. Dictation.

YEAR VIII.

1. Easy questions.
2. Count 20 to 1.
3. Ball and field.
4. Find similarities (Elementary)
5. 6 numbers.

*6. Vocabulary.
*7. Change.
*8. Date.
*9. Reading (2 facts).

YEAR IX.

1. Months.
2. 9 coins.
3. Definition (Genus).
4. 4 digits backwards.
5. Finding rhymes.

*6. Count value stamps.
*7. Reading (6 facts).

YEAR X.

1. 5 weights.
2. 3 words 2 sentences.
3. Memory drawing.
4. Repeat sentences : 20 syllables.
5. Healy-A. : puzzle.

*6. Vocabulary.

YEAR XI.

1. Absurdities.
2. Difficult questions.
3. 60 words in 3 minutes.
4. 7 numbers.
5. 3 words in 1 sentence.

YEAR XII.

1. Mixed sentences.
2. Picture interpretation.
3. Ball and field.
4. 5 digits backwards.
5. Find similarities (Advanced)

*6. Vocabulary.
*7. 3 rhymes.

YEAR XIII.

1. Suggestion (lines).
2. 2 or 3 problems.
3. Interpretation : fables.
4. Definition : abstract words.
5. Arithmetic reasoning.

YEAR XIV.

1. 26 syllables.
2. Definition (abstract).
3. Induction test.
4. Reversing hands clock
5. Vocabulary.

YEAR XV.

1. Cut paper.
2. Differences (abs.).
3. Reversed triangle.
4. Enclosed boxes.
5. 6 digits back.

YEAR XVI.

1. Summary.
2. Interpretation : fables.
3. Code.
4. Repeating sentences.
5. Vocabulary.

*6. President and king.

Curtate Binet Scales.—E. A. Doll, at Vineland, devised a shortened B.S. Scale for ordinary practical routine with children from V to X years, which may be set out as follows, using money (in the U.K.) for stamps (in the U.S.A.) in the second tests for VIII age.

A.

V.

Compare two weights.
Choose prettier faces.

VI.

Count 13 pennies.
Detect lacks in pictures.

VII.

Shew right and left.
Copy diamond.

VIII.

Count from 20 to 0.
Count (money) stamps (six copper coins).

IX.

Make change.
Invent sentence.

X.

Give rhymes.
Reproduce design.

Each of these tests has a mental age value of six months. An alternative shortened scale is—

B.

V.

Distinguish a.m. from p.m.
Define by use.

VI.

Execute three directions.
Solve " patience."

VII.

Describe action in pictures.
Compare verbally.

VIII.

Name days of week.
Repeat five digits.

IX.

Give date.
Name months.

X.

Recognize money.
Repeat six digits.

These scales generally give results, especially in feeble-minded, two or three months below the complete B.S. Scale, but take very much less time.

Most investigators have a few more tests in their armamentarium, some one of which they may favour.

One test which is much quoted in America is the valuable

Ball and Field Test of Terman. (S.R. VIII)

" Now suppose that a ball has been lost in this big round field. We don't know where it is, or anything about it, except that it is lost somewhere

FIG. 71.—THE BALL AND FIELD TEST.
The two right-hand figures as it should be done at age XII.

in the field. Now suppose that you had to go and find it. I want you to take this pencil, and shew me how you would go about looking for the ball so as to be sure not to miss it. Begin at the gate and mark for me the path you would take." This test is for year VIII and is passed if the child shews evidence of a definite plan of search. It is also used for year XII but a superior plan, either a spiral line, or parallel transverse lines joined at the ends.

Comparing Objects: " Similarities."—Two objects such as wood and coal, cat and dog, correspond to age VIII. Three words such as snake, cow, sparrow, for age XII (S.R. VIII and XII).

Transposed Clock Hands.—Imagine the clock hands at a certain time to be interchanged. What time would it mark? is for age XIV. A clock as seen in a mirror is a more difficult problem still (S.R. XIV).

The Naming of Colours.—Number 17 for Age V.—The naming of colours was a subject worked at by Warburg (*Munch. Med. Woch.*, 1909. 2511). The matching of colours is an innate quality which has no special relation to intelligence. In the Binet test, four saturated colours—red, green, blue, and yellow—are used. Warburg considered that at 6 a child should name red and black correctly, and if at 7 it named brown and red, it need not be considered for a special school. The order he found for naming was white 99 per cent., black 99, red 94, yellow 87, green 73, blue 71, brown 50, grey 36, by presumably six-year-olds. Girls do better than boys.

The De Moor Size-Weight Illusion is a valuable test for low grades. Two wooden blocks are used, $4 \cdot 5 \times 11 \cdot 0 \times 7 \cdot 5$ cm. in one case and $4 \cdot 5 \times 11 \cdot 0 \times 30 \cdot 5$ cm. in the other case. They are

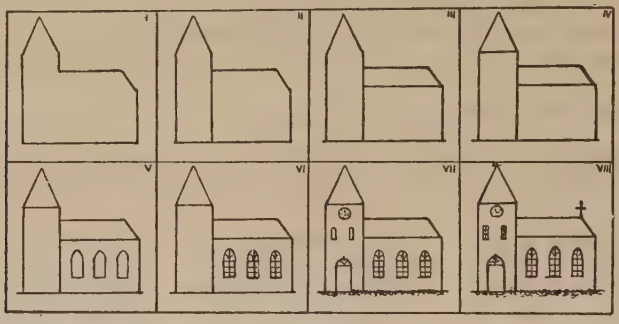


FIG. 72.—EIGHT CARDS OF ONE OF HEILBRONNER'S TESTS.

loaded to be exactly the same weight. Normal persons, and those above 8 years old mentally, on handling and looking at them, judge the smaller one to be the heavier. They are allowed to be compared in any way by hand and eye.

Age IV is able to do the test, only 40 per cent. have the illusion; age VI 60 per cent.; and age VIII and over, all have the illusion. This is the only test in which one succeeds by being wrong.

Heilbronner's Test.—Several series of cards have objects first in barest outline, then a little more detail till gradually by the fourth or fifth card of the series the complete object is represented. One series will have a lamp, another a book, a clock, and so on. The most incomplete one is shewn first, then the next until the child is able to imagine what it represents and name the object. The score is a point for each card, but a point is deducted for each card which the child is unable to recognize.

Ebbinghaus has what is called the *Completion Test* for power of combination and imagination somewhat on the lines of the above. Printed texts are used from which many of the leading words have

been omitted, and the vacancies have to be filled up. In early cases of *Dementia Præcox* the senseless completions are valuable pointers.

The Analogy Tests, much used lately, lend themselves more to Group tests. "Moon is to Earth as Earth is to ——." "East is to West as Day is to ——."

Opposites.—A printed list of words is furnished, against each the word of opposite meaning has to be rapidly written.

Synonyms, definitions, all like the Ebbinghaus test or analogies, are chiefly tests of language which happen to be closely correlated with intelligence in the majority, although not necessarily so in all individuals.

It was probably this Group Testing in relation to language, although special precautions were taken to counteract such influences, that gave the extraordinary records from testing recruits for the American Army, in which whilst only some 5 per cent. of native-born whites were assigned an intelligence level of nine and

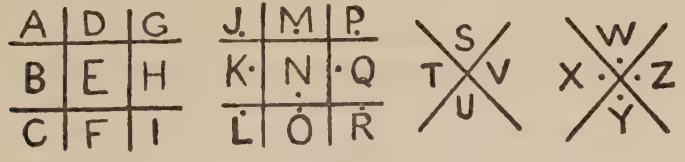


Fig. 73.—THE AMERICAN "CODE" TEST.

a half years or less, in the case of some thousands of foreign-born whites, eleven times the proportion, 55 per cent., were so assigned.

Codes.—A diagram as above is constructed, whilst the child looks on; he notes the arrangement of the letters in vertical rows and against the clock, and the dots used in the second and fourth. Once the scheme is known a cipher can be constructed by using the parts of the diagram nearest the letter without the letter; thus "war" would be written V J F. He is then asked to write one or two words without seeing the diagrams, or drawing them, and purely from memory. It is a test for fifteen-year-olds, XV, but the writer feels sure he would fail if suddenly confronted with it (S.R. XIV).

In the Binet-Simon Scale a child either passes or fails in each answer. He gets 0 or 1; although it may be worth $\frac{3}{4}$ or $\frac{1}{2}$. With the Terman Stanford Revision each test passed is equal to an additional mental age score of a couple of months. This is certainly detailed enough, and probably it is like working with seven figure logarithms when five figured would be sufficient.

The Yerkes Point Scale.—Huey suggested giving marks for answers on the Binet Scale. This idea was worked out by Yerkes

and his colleagues, and published in their book (Yerkes, Bridges, and Hardwick, *A Point Scale for Measuring Ability*. Warwick and Yorke, 1917).

They utilized 19 of the Binet tests, added an analogy test and assessed each part of the answers in marks or points. Thus age X, Sentence Building with Three Words, an answer giving a single sentence would have 4 marks, whilst if two sentences were used only 2 marks would be gained. So, the reaction to three Binet pictures are marked: enumeration, 1 point each; description, 2 points each; interpretation, 3 each.

It is possible by working backwards and forwards with the tests to smooth out results, giving each point a relatively equal value; the points, however, are not like inches on a foot rule, or the divisions on a thermometer stem. Points here are like the different levels a set of specific gravity bulbs might sink to in a liquid of varying densities. They express relations above or below, but not how much above or below. One somehow does not feel the same definiteness in accomplishment as with the B.S. statement.

They found from measurements in Boston, that separate norms for sex, language, race, and social and economic status would be as important as norms for age. They concluded that for any fine measurements the mental ability of the subject would have to be expressed in relation to the group of which he was a part, rather than on any absolute figures.

In spite of care of the framers and their special precautions, many of the B.S. tests themselves have turned out largely a matter of word memories. Verbalism is one of the lower faculties, suggesting to the superficial observer a spurious appearance of exact knowledge, intelligence, and capacity. In about half the tests the B.S. Scale exaggerates the value of mere words. Binet himself says, "Memory is a great simulator of intelligence."

Binet and Simon expressly warned that it would be idle to think that their scale which gives the level of intelligence, also determines its quality or character. It was devised to aid observation, to complete and control, but not to replace it. It does not even measure amounts of intelligence; it measures differences of age level.

The mental instability which is a temperamental matter of emotions and moods in certain children may affect their moral control without influencing school attainments or varying their B.S. records, yet may make for social insufficiency and misfits in life. And Binet insisted on this and had begun the development of a technique in regard to differentiation of these cases, unfortunately never completed.

A little earlier than the Binet Scale, Sante de Sanctis in Rome

suggested six tests (*L'Année Psychol.*, 1906) which involved performance, and were of value in classing children up to about 9 years, but the wider range of the B.S. Scale seemed to give more satisfactory information, and rapidly replaced them.

Porteus in Melbourne, working with the Stanford Revision, was led to supplement it by a test—the Porteus Maze—which is graduated for age in a series of forms of increasing difficulty, with little use of words. His set of figures can now be bought.

Foreseeing and planning, as for instance in the Ball and Field Test, which Terman added to the B.S. set, is one of the highest faculties. Planning represents positive, and prudence the negative side of conduct arising out of foresight; but prudence in excess means inhibition to the verge of inaction. All these are tested by the Porteus device. It is not a replacement but a supplement to the B.S. Scale, and as the author says, failure in the tests is more significant than success, in diagnosis of future social efficiency.

The first test for the three-year-old is merely to draw a pencil round a diamond-shaped path 7·5 mm. wide, without touching the sides, the diamond being 10 cm. high and 7 cm. wide. The child's method, the number of contacts it makes, and the time to do it are all noticed. There are a series of mazes increasing in complexity for each year of life, which have been standardized as regards mistakes and time to do them. The child is told to look at the figure, and when it sees what is required and how it can be done to draw with the pencil a line from the centre along a clear path to the outlet. There may be no turning back or seeking a better way. Three trials are permitted.

These tests are useful in the later years of school-life, particularly with delinquency cases. The slow and steady plodders doing much better here than with the B.S. Scale. The smart gamin type of child, with pert answers and ready wit, from want of prudence may be brought up short when tested by the maze. Boys do better than girls, age for age, in the Porteus tests.

The scores with this set of tests do not materially vary from B.S. tests in about four-fifths of the cases, but as they test psychomotor abilities as well, Porteus suggests that the best result is obtained by an average value from both sets. The B.S. Scale mainly involves receptor impulses, the Porteus effector actions.

Dr. Herd, in Manchester, found a close relation between the child's capacity for manual work, and its Porteus attainment. In a doubtful case as to whether a child was good enough to be given a probationary trial in a Special School, he would reject it as unfit to profit, if its Porteus score was not 50 per cent. of the normal for its age.

The Porteus tests are only part of a general scheme for social valuation of individuals, evolved by Professor R. J. A. Berry and

S. D. Porteus in Melbourne (*Intelligence and Social Valuation*, Vineland, 1920).

In this Melbourne method every aspect of the case receives due weight in a numerical assessment.

The name and age and a short clinical account of the individual having been set down the following determinations are made, and each finally classed in its correct percentile group. The actual numbers found in the case of a mentally low-grade boy aged 9 years and 10 months are inserted, for example.

1. *The Cubic Capacity of the Brain.*—For this head length (187 mm.), head breadth (140 mm.), and head height (138 mm.) are taken, and by Lees formula (p. 20), the cubic capacity (1378 c.c.) of the brain is calculated. From Berry's tables this is found between 1349 c.c., the 80 percentile and 1380 the 90 percentile, and by interpolation is placed at 89.

2. *The Physical Classification.*—The standing stature (1249 mm.) is in 23 percentile, sitting height (707 mm.) is percentile 61, weight (25 kilos) is in the 27 percentile. The physical class (37) is the average of these percentiles.

3. *The Psycho-physical Average.*—The right grip is 13 kilos, that is percentile 20; left grip of 11 kilos is percentile 11; vital capacity only 950 c.c. is in percentile 3. The average of these gives 11, the psycho-physical value.

4. *The Combined I.Q. is then taken.*—The Binet-Simon age gives B.S. value I.Q. 35·6. Porteus tests give a I.Q. value of 45·7. The average of these gives mental assessment more correctly than either separately, that is I.Q. 40·6.

These measurements and values are recorded on an examination card, and marked on a chart which it contains, on which also are marked graphs shewing the limits of normality. At once all the values of this case are seen to lie below the limit of normality except the physical classification, and even this is far below average for boys at the age and social level of the one tested.

This combination of measurements seems more reliable in final interpretation than any single group of measures, however refined or accurate. It will take more time, but gives a correspondingly reliable judgment by correlating measurements with clinical, personal, and environmental history. It is the collating of all evidences that gives weight, especially in borderland cases, where environmental conditions may determine the result. A detailed demonstration by Professor Berry is given in the *Med. Journ. Austral.*, 1925. ii. 352.

Other methods of testing observation and power of making adjustments are useful, especially when they test readiness to vary a performance. The old form board, used by Seguin to train sensory perceptions of imbeciles, is utilized in several varieties. The commonest is a rectangular board about 40 × 60 cm. There are ten recesses in the surface about half a centimetre deep. They are of various forms, circle, half-circle, triangle, square, star, and

so on, corresponding to the shapes of ten wooden plates about three-quarters of a centimetre thick.

The board with objects in position in their holes is shewn to the child; they are then dumped out in a heap, the board is laid flat and the candidate is told to replace the wooden objects in their own holes. His method, mistakes, and time are noted.

This common form board has been standardized by J. E. W. Wallin (*Journ. Ed. Psychol.*, 1916. 17), who sets out psychomotor norms for the average performance of three trials. His standard board was 78002 in Stoelting's catalogue, and he distributed his norms in central half-years of age (i.e. 6 years is 5·8 to 6·3). The curves are for normal children. He finds psychomotor capacity varies with grade of intelligence and type of child. The bright surpass average, these the dull and backward, and feeble-minded follow according to their various grades and generally surpass

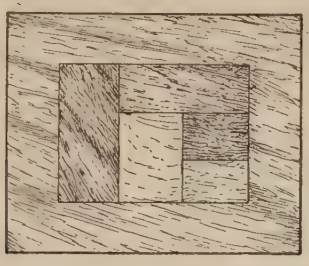


Fig. 74.—HEALY FORM BOARD. CONSTRUCTION TEST A.

epileptic. Normal boys are surprisingly just a little above girls in this test, as indeed they are in Porteus tests.

A simple form of Goddard's adaptation board (*Training School Bulletin*, 1915) is probably the best for VIII years. Varieties or developments of form board devised by Healy are sometimes used and found very useful in young delinquents in bringing out their inability to handle special situations.

The simplest construction puzzle (A), the Stanford Revision assesses as equal to mental age X, if done three times in five minutes. It rapidly demonstrates individual capacity to profit by experience, in contradistinction to the defective, who repeats mistakes.

In the more complicated form (B) it brings out capacity to plan out and see possibilities, and also to profit by trial and error. An individual of mental age X should manage this three times in five minutes. Dr. Clara Town, testing a group of five- and six-year-olds, found the majority (23 out of 41) fail to do puzzle (A) in ten minutes, the remaining 18 did it in an average time of 101 seconds. The numbers were about the same with (B), the average 164 seconds.

Healy's completion test is useful for illiterates or hard of hearing

and deaf cases. A picture pasted on a board has ten squares sawn out, each is about three-quarters of an inch wide, and corresponds to an object in the picture, a hen, a horse's head, the sun, a girl's hat, and so on. These squares are mixed with a few others, also with pictures. The child has to select squares to complete the picture in five minutes without more than one glaring mistake. He is likely to fail if the mental age is below IX–X. Dr. Boome, in London, testing normal children, thought it applicable as a test of capacity for children of 11 or over. Pintner and Paterson have attempted to devise a performance scale, which avoids the use of language. About a dozen tasks of the form board and picture completion type are used. The book description, published in 1917, does not impress one as the B.S. Scale did.

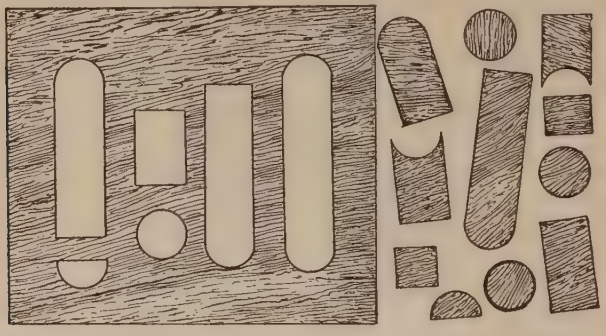


Fig. 75.—HEALY FORM BOARD. CONSTRUCTION TEST B.

The B.S. Scale and other tests give levels of intelligence above or below average. But what, after all, is intelligence ? It seems to be the result of all nervous actions, the sum-total of automatisms, reflexes, and higher inhibitions and control by the supra-granular cortex. The mathematical psychologists conceive it as detailed capacity, combined with a central factor. This last probably being the expression for the general but varying action of various parts of the supra-granular layer.

Intelligence is the power to construct or imagine mental conditions which correspond to an environment. This is what Stern defines as the general capacity of an individual to adjust his thinking to new requirements. So long as a person is able to adjust his conduct to be in harmony with others in his environment he is normal whatever be the amount of his intelligence.

Goddard attempted to illustrate adjustment (1915) by taking the daily life of the inmates at Vineland, regardless of their actual ages. Up to mental age VI they can do short, simple tasks and wash dishes ; up to VIII run errands, make beds, and do light

work; at XII can use machinery, care for animals, and work without supervision, but cannot plan.

These Vineland activities are carried on, however, by "experienced" folk, older chronologically than the mental ages. For the *same mental age*, bright children are not equal to dull in motor performances, being, of course, younger and of less experience. Healy criticizes this scheme as unsafe for prognosis or treatment.

Based on the same kind of an idea is the Stenquist's mechanical Assembly Test used in Baltimore, a box of various small instruments and objects, such as a window latch and so on, of which the candidate is asked to explain the purpose and use and fit the parts together.

It measures a capacity of boys relatively independent of the intellectual ability of other tests. What are sometimes called motor-minded, endowed with the capacity of manipulation of objects, and successful in objective mechanical occupations, although they may be wanting in verbalism, and failures in mere academic work, are types selected by their capacity with the Stenquist box.

Gaw (*Performance Tests*, H.M. Stationery Office, 1925) also examines tests for vocational abilities.

All these tests are individual, but sets of tests have been devised by Terman, Otis, and others for testing in masses—Group Scales; they are chiefly of educational interest, and as in American Army tests, of social value, but need not be further dealt with here, although some of their results will be mentioned later.

Should the medical school-work become an educational service they would be of value in selecting all exceptional children who deviated more than a certain amount, say, in lowest and highest percentiles, for individual examination and special educational treatment.

The B.S. Scale gives relative values as the only way of measuring intelligence, each child is placed above or below the average, and then it is attempted to express the amount in years of advancement or retardation. The Point Scale amounts to the same thing. The value thus got is called the Mental Age, and is expressed in Roman letters.

By whatever means tested, the age at which the actual work done should be a normal accomplishment, divided by the calendar age, gives a quotient which William Stern (*Intelligenzprüfung*, Leipzig, 1915. 55) called the Intelligence Quotient. It is better expressed as the percentage the mental age bears to the actual age.

$$\text{Intelligence Quotient} = \text{I.Q.} = \frac{\text{Mental age} \times 100}{\text{Calendar age}}$$

This is extensively used, although it has considerable drawbacks. It only has a meaning during the growth period, and after that the

chronological age is taken as 16, or the I.Q. would become nonsense. Possibly this age of 16 is too high, and E. A. Doll suggests 13, but may be influenced by his Vineland experience of defectives.

The I.Q. is really only strictly satisfactory when all compared are of similar calendar ages.

Scattering in the B.S. Tests.—When groping in early days of school medical work for tests to separate those requiring special education from normal dull children, evidence of any obvious irregularity in order of development of function was held important. Later Doll (*Training School Bulletin*, May 1916), at Vineland, suggested that in general a normal child develops more consistently than one who is a potential defective.

The usual rule of taking the year in which all tests are done as the basal year, and adding a year for every five more tests done successfully, with a normal child age VIII would be scored by all the tests for VII, three for VIII, and two for IX. Another child may come along and score test VIII, but it may be made up of basal year V, four tests at VI, four at VII, three at VIII, two at IX, and two at X. This last is scattering in the tests, and held by Doll as evidence of potential feeble-mindedness. Scattering is most common, however, among epileptics. As a result of special enquiries in 840 cases at St. Louis, Wallin concluded that scattering in morons and normals was equally common (*Psych. Clinic*, 1917. 179). Since then Wells and Kelley (*Am. J. of Insanity*, July 1920. 17) have shewn that psychotic individuals scatter markedly, failing below their level in the serial arrangement of weights, or rhymes, whilst vocabularies are least affected, and formal memory tests passed far above their level.

Distribution of Intelligence Levels with Age.—The distribution of level of intelligence through the life of an individual is similar to growth of other general functions, as, for instance, muscular activity. Indeed, Professor Matsuma (*School Hygiene*, 1911. 41) set out an age-scale for the number of beans lifted in a minute with chopsticks, using right and left hands, and then both hands. His numbers correspond to what is found for intelligence, or rather, the capacity to make rapid adjustments to environment which is the test of intelligence. It rises at a slightly varying rate to a maximum soon after adolescence, remains steady for about ten years, and then slowly and steadily falls. The babe has the actual mentality of an idiot, the toddler of an imbecile, but mentality increases with each year of life. Depending on the very recent and enormously variable supra-granular cortex there are possibilities of all kinds of variation or arrest in growth, and the ultimate adult intelligence depends on how soon, and how much arrest in growth occurs. As an American writer puts it, "Man begins as an idiot, and ends as an idiot." Even in the cradle defect may be suspected,

and intelligence may shew. The normal child should hold up its head by 4 months, sit up by 6 months, stand by 10 months, and begin to try to walk soon after its first birthday, having passed the quadrupedal stage, but some defectives take much longer, up to another year. The normal child should begin to speak at from 12 to 15 months, but the history of some defectives shews no speech till 2 or $2\frac{1}{2}$ years.

C. D. Mead (*Ped. Sem.*, 1913. 460) found that the children of teachers first took a step unassisted: boys 14 ± 1 month, girls 13 ± 1 month; and first used a word intelligently: boys $16{\cdot}5 \pm 2{\cdot}8$ months, girls $15{\cdot}5 \pm 2{\cdot}7$ months; the averages for normal children thus being: walk $13{\cdot}5 \pm 1$, talk $15{\cdot}8 \pm 2{\cdot}8$ months. With 144 cases at the Indiana School for Feeble-minded he got F.M. boys walk 22 ± 8 months, girls $20{\cdot}8 \pm 7$ months, and talking F.M. boys $55{\cdot}8 \pm 13{\cdot}5$ months and F.M. girls talk 30 ± 12 months. For both sexes of F.M.'s walk $21{\cdot}6 \pm 7{\cdot}6$ months, and talk $34{\cdot}4 \pm 12{\cdot}8$ months.

The foundations, on which intelligence is built, mature at very different rates. Prodigies generally possess a talent which matures early, and sometimes seems to regress; or at least, they lose the power of keeping up their advance in that particular direction. We had a doctrine in London, twenty years ago, that many defectives attained an early maturity in their defective wits, and formerly many left school at 13 or 14 on the report "has reached mental limits."

The same thing happens in ordinary work. Latin, grammar, music, or arithmetic may be subjects in which a scholar early reaches his limit. There is a mental limit for everyone, and a student may seem quite brilliant up to the point of arrest about puberty, and then be outstripped by others. Apart from cases of dementia præcox, which usually regress, the mental limit is well known by coaches at the Universities. They know that a boy brilliant at school may fall behind; and almost everyone can remember half a dozen students who, becoming fellows of their colleges on their past, disappoint all by sinking at once to mediocrity.

In discussing the growth of intelligence, Yerkes and his colleagues estimate that during the fourth year of life intellectual ability, always to be understood, of course, as measured by the Point Scale, increases by more than 50 per cent.; during the fifth year by scarcely more than 30 per cent.; during the seventh year of life by approximately 15 per cent. They note that extraordinary intellectual ability is fairly common up to eight years of age, then very uncommon. It then develops less rapidly, until in the thirteenth year it increases by only about 5 per cent.; finally between 16 and 18 the increase is slight and irregular, ceasing almost entirely about

18 years. These percentages are estimates on their Point Scale, as there is no concrete measure of intelligence. Any value given is a relative not an absolute measure.

The story can now be completed by following group and individual testing of medical officers of the American Army during the War. There was no variation in level between 20 and 26 years of age, when it began to descend slowly to 35, then more rapidly, till by 60 it was only 76 per cent. of that registered in the youngest groups (*Bull. Med. Research*, Washington, 1921. 483).

It was early set out as a result of scale testing that retardation in defective children was uniform. A child retarded two years at the age of 8, would be retarded three years at 12, and presumably, four at 16, and would probably go through life with the mentality of XII, the average twelve-year-old child. A certain variation, at

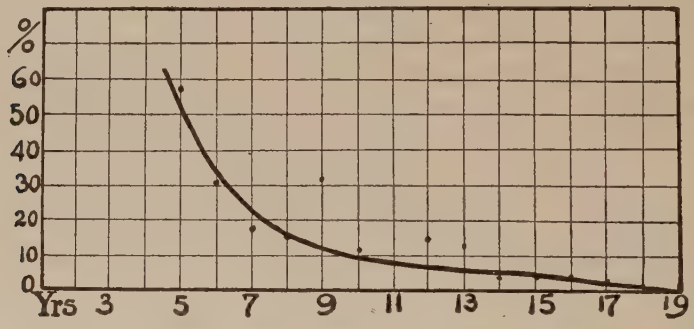


FIG. 76.—CURVE OF RATE OF INCREASE OF INTELLECTUAL ABILITIES FROM YERKES' POINT SCALE MEASUREMENTS.

least 5 per cent. and probably even more, has to be allowed for experimental errors.

This, if true, means the I.Q. once stated holds for any age. Burt, however, on repeated testing, and in 34 cases it extended over five years, found that there were changes. The average fell from 63·7 to 57·1. In a large group tested over shorter periods, some fell, some rose so much, that he recognizes some children as growing mentally with a spurt towards adolescence. The amounts, however, are scarcely material. He considers a slow and regular fall in the I.Q. as distinctive of neuropathic and psychopathic cases. It is doubtful. Just as Doll suggested potential moronity among apparent normals, so Burt seems to suggest potential normality among the apparent defectives. This was certainly common at one time, but due to poor diagnosis.

Terman's conclusion as to the practical influences of any change is that superior children at one testing will be superior at the next, average remain average, inferior still remain inferior, and the

feeble-minded do not improve. That is probably a fair statement of the sum of testing results. In London, normal children advance nineteen-twentieths of a mental year annually, the mentally defective about half a mental year in the same time. There are definite exceptions to all these general statements, but they are uncommon. In his Annual Report for 1921 Dr. Fraser plotted out the mental ages and I.Q. of children in a Hull special school, and from his diagram the figure is a little altered and illustrative of the mental growth of these children as deduced from ordinary school testing.

More recently the constancy of the I.Q. has been specially observed by Gray and Marsden (*Brit. J. of Psych.*, 1924. 169) who

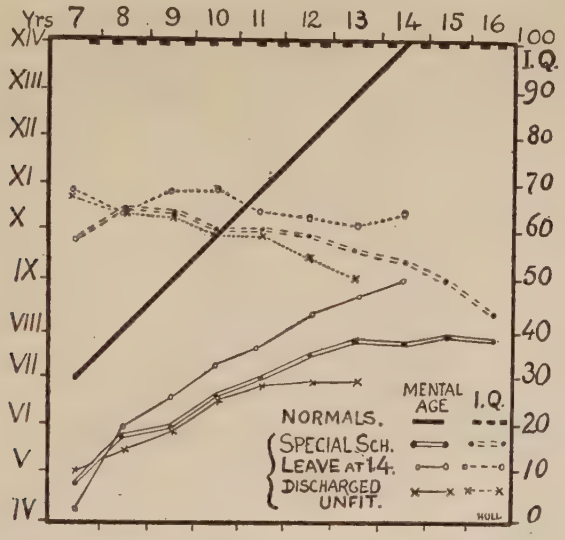


FIG. 77.—AGE AND MENTAL AGE AND I.Q. OF NORMAL AND SPECIAL SCHOOL CHILDREN IN HULL.

find the various factors of age, I.Q. interval between tests and sex without material influence, and calculate the chances of changes of various amounts. W. Stern discusses the constancy of intelligence in the sense in which it has been discussed above, in a recent paper (*Psychol. Clinic*, 1925. 110). He points out that the method of constructing the intelligence scale means that in normal individuals the I.Q. would always appear constant; further, the enormous mental change at puberty is in no way indicated by the results from the I.Q., so that its constancy in any absolute sense is really an artefact.

Variation in Distribution of Intelligence.—The variation in distribution in the population is important. In my first Report to the L.C.C., 1905, I was able to base on the clinical experience of cases seen, an estimate of the distribution of intelligence, which

although it had not the numerical accuracy given by exhaustive examinations by B.S. or other scales then non-existent, stated results which have not been varied, by the enormous amount of work since done. "If by any means we could make a numerical estimate of the mental capacity of each individual, few cases at one end would represent geniuses, a few at the other end would be idiots, and one class would gradually pass through the merely clever, through the great mass of mediocrity to the dull, and then the feeble-minded, but each succeeding class would gradually merge into the other without any sharp break.

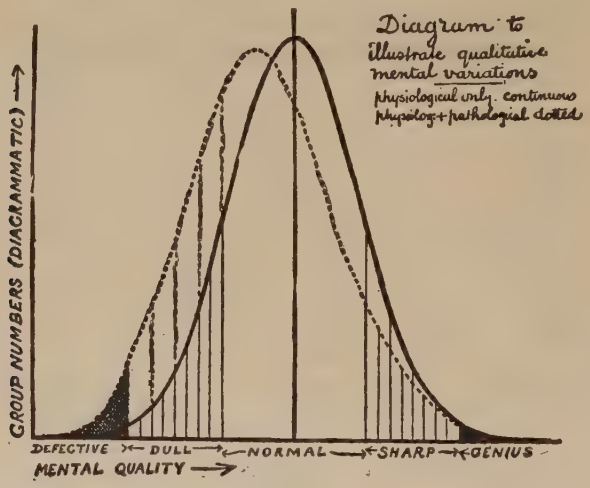


FIG. 78.—NORMAL DISTRIBUTION OF MENTALITY IN POPULATION.

"If now an area equal to one-hundredth the whole is cut off one end, this represents the estimate of the Committee on Feeble-Minded Children as to the class to be provided for by special education. But there is still a considerable mass of children who from various causes are below normal, and who even if they pass through school attaining Standard II or III before they leave, receive no such benefit as they would if educated with special regard to their hindrances. These, so far as the imperfect means at command allow, may be estimated as amounting with the feeble-minded to 10 per cent. of all, and this represents the class presently to be referred to who require education by intermediate schools." The effects of disease always depress function, and the result of it is seen in the skew of the dotted curve increasing the proportions of defective.

Had this, and the paragraph following it in the Report, not fallen on stony ground, education would have advanced, perhaps,

beyond its present position in as many months as it has taken years.

Pursuing the same method of classifying children by school progress, Burt, in his *Report on Educational Abilities*, 1917, and since then by the application of the B.S. Scale and tests of his own devising, has been able to give a more exact but very similar account

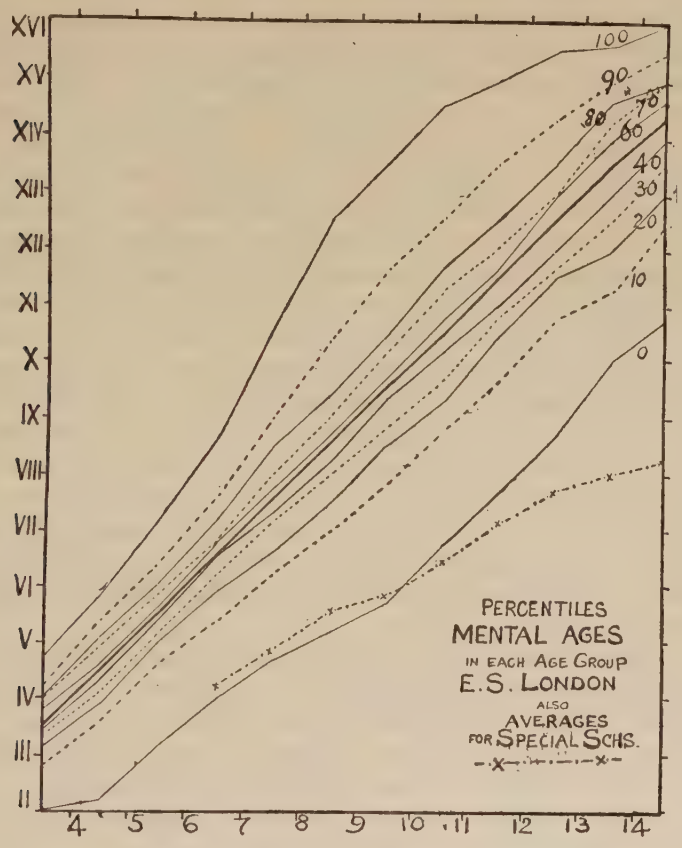


FIG. 79.

of the distribution of intelligence in the primary school population. This may be set out in percentiles from the tables.

The L.C.C. figures, however, refer to a selected population, not including the worst cases which have already been segregated in the special schools or excluded as uneducable. This, of course, is the correct way to obtain standards of attainment. The mental averages of these for each age-group in special schools is marked in on the line with crosses. The other curves give percentile distribution of mental ages in each group, the lower, 0–10 percentile, shews 10 per cent who are about three years in arrears with their

schooling, and should have a type of school adapted to their needs. The figure also shews that drift downwards of those below the average is considerably in excess of spread upwards of high intelligence, as pointed out on the original curve ten years before.

Classification by Intelligence.—The diagram further suggests from its form that distribution of intelligence is closely comparable to physical growth.

In respect of children above average the top 20 per cent. are mentally a clear year ahead of their age, and half of these, the 90–100 percentile, shew still further superiority. In six-year-olds, these ten per cent. are from one to two years mentally ahead, by 7 it has become $1\frac{1}{2}$ to 3 years, and at 8 they have gained 2 to 4 years on their age. After this the relative rate of progress is normal, but they retain their lead till about 11, when the rate slows below normal. Unfortunately, here we must discount the curves, as in the London elementary schools many clever children are transferred between the ages of 11 and 12 years to secondary schools. The slowing down in the curves for the cleverest percentile may be due to this, rather than due to precocity having brought them earlier near their mental growth limits. Dr. Alice Jones (*Psych. Clinic*, xvi. 27) concludes that there is a chronological age-limit above which marked physical precocity does not figure, and that the accompanying mental maturation, when the post-adolescent stability of growth is attained, tends more and more to approach the median intellectual level for the age. That is what the London curves suggest, even when discounted by the scholarship selection.

In analysing the physical characters of London children, these were correlated to school progress by taking one group made up of all the ten-year-olds. In 1906 we found (*Report L.C.C. Med. Officer Education*, 1906. 12), "There is much of interest to learn from the analysis of these returns. By the time children have passed their tenth birthday, accident or chance, opportunity and ability, have distributed them all over the schools.

"The ten-year-olds in our results were distributed as follows :

Standards I.	II.	III.	IV.	V.	VI.	VII.	Total.
80	204	707	860	428	51	5	2335

"Of these 2335 children, representing average samples, no less than 284 have got three years behind educationally—that is, 12 per cent. of the whole are evidently not profiting as they should from the education offered."

Ten years later the Council's Psychologist, Burt, in his *Reports on Educational Abilities*, p. 82, summarizes that 1·5 per cent. of the children are suitable for special schools as mentally defective, and 10 per cent. at the very lowest for backward classes or schools.

It is safe, therefore, to say that one-eighth, that is $12\frac{1}{2}$ per cent., are suitable for education below the level of the ordinary school standard as subnormal. Backwardness is usually taken to connote merely retardation in school subjects, but it is something more than this.

As the curve of distribution of ability closely approaches the curve of error, it may equally be taken that $12\frac{1}{2}$ per cent. are supernormal, worthy of superior education, and that the remaining 75 per cent. remain for ordinary schools.

Considered on mental endowments, about three-quarters of the children are suitable for ordinary schools, and the other quarter for special education, either higher or lower.

The ordinary school child may be taken first, then supernormal, and finally mentally inferior.

The Ordinary School Child conducts itself in harmony with other children and its surroundings. If it deviates the natural tendency is to return immediately to normal conduct.

In respect to academic status, the ordinary school child, whether its status be determined by its school position attained through the accidents or chances of life, or by tests of the psychologist is a child whose school mental age lies between 1 and $1 \pm \frac{1}{5}$ times its chronological age. Variations of mental age beyond this places the child's intelligence in the subnormal, or in the superior class.

We may accept each of these children as a statistical unit, but as individuals their psychical qualities are almost as varied as their numbers. We are now concerned with intelligence, which is measured or expressed by mental ability. Whatever it may be in the single individual, with a half-dozen of them, it is proportioned to physique as shewn by nutrition and bodily development (p. 31). Attention to this physique is more necessary for the State than any academic education. Physique is determined in some measure by heredity, but it must be obvious with such intimate mixture of races as exist in England, that it is almost nonsense to regard the various social strata graded by poverty as representing mental levels of graded hereditary inferiority.

A London school of special difficulty, if the children were fed, clothed, exercised, and taught how superior they are, as well as are Eton boys, would probably soon be on the way to produce as good mental results as that ancient Foundation is sometimes credited with doing.

The healthy animal should be the first aim of State education.

Social Condition and Intelligence.—The good I.Q. does not grow up itself. It develops from contact with life and its opportunities. Miss Arlitt, at Bryn Mawr, tested 342 children, and classified them according to the social condition of the parents. The I.Q.'s averaged for the children of professional, men 125; semi-professional

and high class business, 118; skilled labour, 108; semi-skilled and unskilled, 92.

The correlation between I.Q. and social status worked out by Terman in connection with the Revised Stanford Scale was 0·43 for younger children; 0·40 for middle years, and only 0·29 for the older, which would lead to the conclusion that the I.Q. becomes less dependent on home influence with time, and probably it does, as the child emerges into the wider experience.

Kornhausen, in Chicago, took five schools in wealthy, poor, and very poor districts. He divided the children according to relative school standing, and took the percentage of each class whose parents had telephones in the houses He found percentages, retarded 19·3, normal 32·0, advanced 49·7. The totals being for all the children that 31·6 per cent. of parents had telephones. The correlation he got between school standing and social status, as shewn by the possession of telephones, was + 0·61.

Bridges and Coles (*Psychol. Rev.*, xxiv. No. 1) find that social status and intelligence on the Point Scale correlate highly, more so in boys than girls. This last note makes environment appear more likely than suggested heredity of the classes.

If mental age were determining, the children of the professional classes would enter school two years sooner than those of the unskilled labour group.

All these intelligence testers scarcely look beyond their noses as regards the previous opportunities of the home. Intelligence is a matter of heredity, but not in the way suggested. The more intensive work of Clara H. Town, who studied the whole make-up of the child and then went into the home, sums the opinions which Bradford and London have given the writer. "There is a current notion that native intelligence of an individual decides the social and economic level to which he attains. Contact with the fathers and mothers of this group of children leads one to doubt the truth of this theory. Among those people who are likely to remain at their present social and economic plane were found men and women of superior mental endowment, who, if their careers had started on a higher cultural and economic level, would doubtless be filling a place in the professional world to-day. It is not poverty of mental endowment which keeps the parents of this special group where they are, it is poverty of mental experience. They were not unintelligent, but untutored and uncultivated" (*Analytic Study*, etc., University of Iowa, No. 48. 1921).

Professor Sakaki, before the day of the Binet Scale, wrote of Japan, "The middle classes are most productive of abnormally intelligent offsprings, and particularly the middle stratum of the middle classes, whereas there are few to be found in the higher or lower social grades" (*Int. Arch. f. S.H.*, viii. 509).

The I.Q.'s of thousands of children in London and elsewhere could be materially raised if they had food, clothing, space for play, and playmates in greater measure than is now possible. Play is a natural education.

The group classed a quarter of a century ago, as spurious mental defect, when not due to adenoidal troubles, were mostly these children, physically and mentally starved in poor districts, unseen in some schools, abundant in others.

The Psychopathic or Unstable Child.—Binet had recognized a group of unstable children. If it is attempted mentally to picture such children, probably the best way is to say that they are likely often to react in an unexpected way. The condition is not definitely

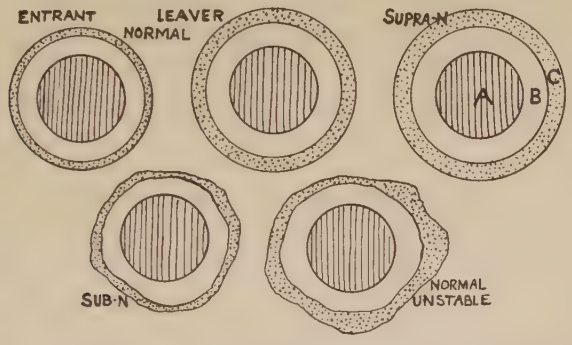


FIG. 80.—DIAGRAMMATIC REPRESENTATION OF NERVOUS FUNCTIONS.

A, the organic sympathetic and ancient nervous functions; B, the neuromuscular instinctive, automatic, and conditioned reflexes; C, the controlling supra-granular cortex. The dotted area represents the intelligence level in various directions in normal entrant, and leaver, in supra-normal, subnormal, and unstable or psychopathic children.

related to intelligence, as this may be rated high, average, or low. It is purely the way in which the nervous system acts, and may be thought of as due to irregular development of the supra-granular layers of the cortex. Some parts deviating up, others down, although the general average is maintained. It is in this deviation, however, that the hope of human progress lies.

Some parts are failing in control, whilst others exercise it normally or supernormally. The term unstable is not a good one, but it expresses the unexpected variations in conduct. The psychopathic conditions which underlie the conduct are often quite normal physiological variations, at other times there are real trends towards diseased states. Incidentally, the study of this class of cases clinically rather upsets the idea of the existence of a single constant central factor of intelligence as a satisfactory working hypothesis. If the normal balanced development of various nervous functions

in different directions were represented by radial lines, their total values might be set out as in the diagrams.

A, represent lowest level organic functions of the sympathetic and so forth, subject to very scanty variations, which are scarcely ever noticed. B, the neuromuscular reflex and conditioned reflex and automatic instinctive systems, but slightly variable, and C, the supra-granular controlling cortex, probably as variable as heights, and variable in different degrees in different parts. Intelligence as determined by special tests is roughly proportioned to the dotted areas. In all, we put A about equal, B is nearly equal, and the differences are chiefly in C. The subnormal gives a generally infantile picture with a tendency here and there towards normality, the supra-normal excels all round, whilst the last "unstable" combines all the characteristics with a general picture of normality. In some one or two directions it tends towards supra-, in others to subnormality. Attempts are being made to determine these directions by making psychograms, but as yet of slight use.

It will always be difficult to get behind the mass of instinctive mental life to the action of the supra-granular layers. Under these conditions of irregularly distributed development the mass of inhibitions, which largely regulate conduct, and especially the finer ones, are poorly but unequally controlled, and the individual tends to form clusters of abnormal conditioned reflexes, and to act in some directions in a very instinctive way. Obviously, with a general normality there is a possibility of kaleidoscopic variety of deviations in the controlling decisions which develop habits and establish conduct, and there may be individuals with similar irregularity extending either to supra- or subnormal intelligence levels.

It is difficult to give numbers for these psychopaths. Probably 5 per cent. of children are noticeable by unusual conduct in school, but not half of these would be considered by the high sounding name, unless they were wealthy and had committed a murder.

The education of life smooths down many to the daily round, whilst impossibility of adaptation gradually makes others advance to actual psychoses or delinquency, and the natural slackening of higher control seems precocious in some of these cases, apart from dementia præcox, so that they even become so peculiar in conduct that they need care, but the number is small.

The drive in conduct comes from the instincts and emotions which should be controlled by intelligence in accord with the conventions of the society in which the child or person is living, but if in certain directions the control is wanting, then the conduct will be variously infantile, primitive, amoral, instinctive, or automatic. Intelligence controls the possibilities of doing, but it is the subconscious which largely determines whether these possessions are lived up to. Emotions and instincts determine the will to do.

Such slight deviations may determine this in the sensitive supra-granular cortex, the latest evolved and most plastic of bodily structures, that these cases above all are during their developmental period amenable to properly directed education.

The development of the necessary conditioned reflexes, whether brought about by suggestions or by the direct stimulation of painful sensations, will be well rewarded. In some children, however, little return will be made; these later will probably become the delinquents of adolescence, lacking intelligence to properly manage instincts and emotions for the common good.

Delinquency really lies within lines of physiological variation, but will be considered later. If the observer wishes to make progress in knowledge or treatment by education, each unstable or psychopathic case has to be dealt with as a particular instance, and regarded as unique. The causes of the variation will be hidden, only the result of their action shews in the conduct records.

Assessment of the Psychopathic Child.—The first valuable source of information is the errant individual. Nearly all children want to do things, and most can be got hold of by curiosity. Give them something to examine and work with, but neither chide or sympathize in any way. Treat them as human beings of sense, and wait, if necessary, for their story; sometimes again if it won't come, they can be surprised into embarking on the recital. They are the most interesting things to themselves, and will soon come round to this if kept talking. Let it all come out, but avoid the slightest lead or suggestion of its being anything but part of the general notes.

Additional enquiries as to home history and environment come afterwards, and mental testing either with the B.S. Scale and then performance tests or vice versa will come in during the course of enquiries, when the examiner has broken the ice successfully. No accuracy of intelligence testing or refinements as to I.Q. will make up an estimate of personality.

Varieties of Conduct.—As in most cases much of the controlling mechanism seems to have remained infantile, one expects and finds them extremely liable to suggestion, and with this they may have all the secondary hysterias, fears, and obsessions. The egotism of the very young child may still persist, so that others become mere objects about it. The environment may only exist for the child's pleasure and glorification, a narcissism which is very common in girls, and the artistic and often degenerate boys who deem themselves musicians or write poetry. Conduct may shew marked mental defect, when intelligence tests point to normality or even supernormal intelligence. Mental defect does not therefore mean intellectual defect.

The feature of the abnormal conduct is mostly that quite trivial

causes which in the mentally normal individual would either never be perceived or be promptly relegated to the limbo of forgotten memories, here sets off a violent discharge of higher reflexes with their accompanying emotional outbursts. Logical thought may give place to fantasy, and the imagination produce purposeless lies and long, wordy romances in quite young children.

An instance where a delicate little chubby, blue-eyed girl reported that the teacher had pulled out her hair by the roots, which was confirmed by another equally attractive infant, who had seen the little tuft of hair fall on the floor, led to the appearance of the teacher, who only pleaded ignorance of all the facts, before the Teaching Staff Committee. The doctor's advice being sought, he certified the child as suffering from a bald spot due to ringworm. The whole thing was a pure fantasy in a neurotic child, and suggestion in her companion.

It is not entirely want of adaptation, for some of these folk with their partly infantile mechanisms retain the child's extraordinary power of sensing another's moods. They fall in with the slightest indication of their interlocutor's standpoint, may be quite lovable, and have a pleasing smiling emotional way, a plausible outpouring of phrases and promises and excuses in abundance.

The Rev. Stuart Headlam once began his reply to a Chairman of the L.C.C. Education Committee, by referring to this person, "famous for always knowing the right thing to be done, and for having a thousand reasons for not doing it," thus neatly hitting off the type of a plausible, untrustworthy, and evasive mentality.

Whilst young they are no more purposeful swindlers than the purring kitten. It is a mere instinctive adaptation to the mood of the moment, but it is also the attitude of the morally weak in later life. They may have no intention or capacity for carrying out their promises or ideas made when keyed to this pleasant mood. They are victims of some persistent ideas and the moment the environment changes, they revert to their previous position, driven by underlying forces of possibly self-gratification and an anti-social nature.

The individual who is classed by some as a moral imbecile is a rare, but clear clinical type, having little regard for ordinary ethical standards, save as they can be taken advantage of to coerce others, or to help the underlying egotism, thirst for power, pleasures, or whatever it may be. They are dealt with as moral defects. There is a class of child easily led. Suggestions are readily received as their own. They may be clever pupils, brilliant and accomplished scholars, but are usually highly emotional, even hysterical, in their behaviour. In later life their emotions are so accessible to suggestion that they fall the prey of any one clever enough to recognize their weakness, and base enough to turn the knowledge to account.

Brilliant and unstable, they manage to float along, recognized and pitied, often later failing through alcohol or drugs. It is want of intelligence, rather than of moral control that usually selects the known delinquents.

The handling of these cases is a matter of common sense. We have not space to detail their multitudinous idiosyncrasies, some are mentioned later as separate symptoms. Inborn, congenital, or hereditary make-up of the nervous system is not likely to respond so well as damage from disease or acquired troubles, but at the same time defects can be accentuated by bad education. The child is not born with a wholly sound brain; it is an average that has defects and excesses, and it is more liable than usual to form wrong adjustments in some of the difficulties of life; these have to be avoided or bridged over in its education.

There is part of the nervous pattern which comes out in little traits and habits not due to education, but purely the spontaneous product of the structure of the nervous system.

Psychasthenia.—The nervous system in its earliest basal relations is intimately connected with the various endocrine glands, and these must be remembered as underlying factors in nervous reaction. Probably with this goes the curious want of resistance one thinks of as psychasthenia. These children feel fatigue easily. They feel unequal to tasks which at times they seem to do easily, tend to unrestrained hysterical reactions. The sympathetic nervous system, too, may react in feverishness, cardiovascular changes, flushings or faintings. When young the ordinary nervous type of thin, translucent, hungry-looking children, often with dark circles round their eyes, gives the picture. It is partly congenital, the result of a poorly built nervous system and partly an adverse environment. Some may even be fat, and yet nervous failures. Contrary to other varieties, this psychasthenia seems to predominate more among girls, and adolescence tends to accentuate it for a time. It has a considerable psychical factor, as a girl who is complaining of fatigue and exhaustion on a holiday may do miles of walking, climb some thousands of feet, and never say a word, till it has been all gone through, and the old condition returns. They respond badly to any special treatment directed to the condition. General hygiene is best. The fatigability of the nervous structures may be responsible for sudden switching off in emotional conditions from one tone to another, laughing or crying by turns. They work quickly and well for a minute or two, attention is exhausted, and work ceases. They are lively, humorous, and witty at times, bored and tired and disgruntled at others. The instinctive drive seems to be lowered in these, but all or any of the general conditions may also, though uncommonly, be the result of pure psychical conditions from environmental changes,

so that on the surface they are to be suspected as psychasthenic, rather than surely diagnosed.

Environmental Conditions.—Many shew a muscular want of tone. The sympathetic system is not maintaining the high-water mark of humanity in a good erect posture. Relaxation of spine and joints, forward stoop of the head, sticking out shoulder blades, are all characteristic of deep-seated nervous slackness. Cameron (*The Nervous Child*, 1924) especially has re-insisted on these attitudes in the stance of young, nervous children. He has drawn a good picture of the child's earliest efforts to accommodate itself to a comfortable existence, and of the effects of suggestions of those around it in the way of developing fears and phobias. The " only child " is notorious for its self-centred misery causing later want of adaptation. Unfortunately too often the mother is the chronic stimulus, negativing both natural and educational aids.

In the earliest matters such as feeding, the suggestions, hints, hopes, and anxieties of the mother are taken in by the child, all the more readily the more intelligent it is. So, too, any physical disability may fix its attention and its interpretations in harmful ways. The child, as a means of self-protection, wants attention, and anything that attracts attention may be developed into almost a conditioned reflex, so that a child may have to vomit, or cry, or refuse to do what is wanted, merely as an acquired habit. The child who does not let go of its mother's apron-strings by the age of 3, may develop undue and lasting dependence as a nervous habit.

This gradually tinctures its whole response and may be a trouble in school. Personality is blighted. The response to strange surroundings in most is shyness, apprehension, silence, and inaction, and even failure or inability to work. This may develop to a chronic condition in the rarer kind of suppressed child if unadapted. Even without actual breakdown, its life may be spoiled by its constant suppression of things which its brain and surroundings make it believe to be wrong. If they are got at, and the child reasoned with, or the troubles explained, the symptoms may all vanish. Some are diffident with strangers, anxious to please, and cringing in their manner in a way that suggests some subconscious effect from sense of inferiority.

The want of higher attentive control in unstable children is often seen, as indeed it probably is in everyone at times, by a kind of reversed thinking. There is an outcropping of sensations from the subconscious, and the attention follows these into ideas of a dreamy wool-gathering which may lead to fantastical day-dreaming. The gift of imagery in a young child may be merely a symptom of uncontrolled attention. It is common in school in the type of unstable child, and is easily cultivated by emotional, dramatic, or imaginative educational methods.

The apparently intelligent child who hears well and does not attend or concentrate has generally contracted this inattention as a bad habit, and its lack of attention is due to a wandering attention directed to some imaginative train of thought, often quite fantastical, or else it is superficially following a flight of ideas suggested by the surroundings.

The child left to itself, with its comparatively unskilled brain, easily builds terrors from the daily happenings of life, not only night terrors, evoked by some dyspnœic or other reflex sensation, but exaggerations of ignorance which may suggest an idea, and following this, all kinds of functional results. Fortunately, a few more hours, and the events of the day, playing on the suggestible mind of the child, may wipe out all predominance of the idea. If, however, it was powerful enough, or the child's mind more easily impressed than usual, or the behaviour attracted the attention of others, and their looks or words reinforced the child's idea, this may have duration, and produce symptoms in imperative ideas, or definite hysterical forms. Hysteria is functional, in that all its symptoms are the result of ideas ; it may be reinforced by unsuspected ideas, and equally, especially before puberty, its symptoms may be removed by skilfully directed ideas. Its cause, however, is the unhealthy neuron, whether due to hereditary pattern, want of nutrition, education, or exercise.

Tics occur in neurotic and hysterical children. The recurrent act, whether winking, shrugging, twitching of face or mouth, biting the nails, or whatever it may be, represents a useful physiological act ; at first it is almost voluntary, but at last becomes a useless habit, and voluntary inhibition results in an intolerable need. Tics are very common among the Latin races. Between 20 and 25 per cent. of the Paris children at school at some time shew them. It is only as a result of strain, fatigue, or debility that they shew in English children, and usually yield easily to suggestion. Occasionally some tic may be evidence of beginning psychosis, but this is very rare in school children.

Various mechanisms of substitutions may be exemplified in these tics and spasms, twitchings, curious attitudes of head or shoulders, nail-biting, and so on. Imitation, or the desire for attention, may produce spasms or paralysis, twitchings, and tremblings, "Zitterkrankheit," hiccups, stammering, more rarely deafness, and common but rarely noticed, the various functional amblyopias. They mostly come out in harassed, overpressed, and under-nourished children.

These may sometimes be accompanied by the neurasthenic group of symptoms, which, however, themselves often constitute the picture, where sensory impressions, which should be dealt with subconsciously, become troublesome. Early fatigue, exhausted

and indolent feelings, inability to work or play, irritability to posture, light or sound, headaches, sleeplessness, or want of appetite, all or any may become obtrusive. The home account may be of worries about work, untidy habits, indecision, always in a muddle, hours wasted in washing or dressing, dreaming of lessons, night terrors, or even sleep-walking.

The family doctor hears more often than the school doctor of the various classes of digestive troubles, vomiting, constipation, or abdominal pains and aches, frequent micturition, or even incontinence. Attacks of what is called weakness of the heart, shortness of breath, asthma, spasmodic cough, and all varieties of functional pains, which may be manifestations of functional nature in these children, but from which, as a rule, however much they suffer, they do not appear to get any worse. In older children, particularly girls, there are varieties in cause so common that they can almost be grouped. The strain of a girl's school where life seems concentrated round examination subjects, and frivolities are taboo, often shews in a breakdown in which the girl cannot learn ; she has suddenly gone dull, possibly has reached a mental limit, but more often it is due to some previous period of uncomfortable life—a child whom no one wanted, brought up by an aunt or stepmother, or more common still, a child from a home where there have been troubles and the parents finally separated. This last, too, frequently crops up in young teachers after a few years of work when the strain begins to tell.

Another type in the teacher at the same stage and sometimes also in a girl going in for one of the senior examinations is where a conflict begins as to what is the good of it all, or is this all life has to offer. It is generally a good, healthy girl who begins to realize the threatening possibility of *la vie manquée* and rebels. Politics or dancing classes are worth suggesting, as if they take them up these means appear to be good forms of sublimation. There are cases, too, presenting a somewhat similar picture superficially, which may be the beginnings of a serious alteration, dementia præcox (p. 409).

Whilst in the case of the young child the mother has to be studied, and her persisting influence averted, with the older ones the family in the past, and now in the present, the whole social outlook needs review, and sometimes it is a surprisingly narrow orbit in which even the adolescent exists. In all cases, young or old, nothing but good can come from an encouragement to tell all they think about the things surrounding them, and the popular remedy of psycho-analysis should only be a rare and last resort. Most cases of this the author has accidentally come across seem samples of extortionate quackery, too often leaving the patient worse.

As a rule, results are easily attained without major operations of this kind. It is only from clinical knowledge and in the school of experience that one acquires almost subconscious diagnosis of these cases and here and there at once selects one which will not improve without re-educative suggestions through analysis.

Causes of Variations.—Whether these cases are mainly due to pure physiological variations, causing irregular growth, or whether the developing supra-granular cortex, which belongs to epithelial structures, may be affected in its evolution, by trivial disturbances of nutrition, as are other developing epithelial structures, such as the enamel of the teeth or the lenticular fibres in the eye, must be left to the future.

Probably natal and prenatal care has a part to play in the evolution of a well-formed brain layer in its latest developmental stages, important for the future of high mental control. Even such coarse happenings as "fits" must play their part, so that hygiene here should be a valuable prophylactic, and even prenatal hygiene will have a value.

In childhood's years wear and tear of civilized life, hurry and noise of the streets, want of daily sleep, hunger and absence of facilities for safe play in earliest years, will all tend to affect neuronic development and bring about the easily exhausted neurasthenic conditions of irritable weakness that many of these children shew. Too early attempts at schooling in artificial conventional subjects must mean premature functioning for all but precocious children, and any others will suffer. Some residential schools are nurseries of psychopathy from their development of uncontrolled imagination without a solid balance of physical work and exercise. The facts of nature, physical, chemical, natural history collections and arrangements are best for sound mental co-ordinations. All that develops the physical side, sports and games, are also valuable, and to be made the most of in bringing out higher control. For the unstable and nervous child mere academic and literary subjects should be kept much in abeyance before adolescence.

In the past generation there has been a wonderful appreciation of natural education in earlier years, as against spurious results academically, and it has been all for the good.

Extra expense in education should not be wasted on the feeble-minded children, if the personalities of the psychopathic deviates are to be neglected. Many of them, indeed, under such a literary regimen become potential degenerates, if not potential feeble-minded.

So far as a school or any other regular task is concerned, the aim is to convert this task to a conditional reflex, and it is much aided if made pleasant. A joyous learner is a good learner, and if the child does the task with a smile, it is more likely to be repeated

until it is a useful habit. The unwanted habits of evading responsibility, refusing to face facts, procrastination, and inactivity should be replaced by "Do it now," "Get it off your mind." Worry, sulking, shyness, self-consciousness, and all the concatenations of suppressed fears and apprehensions should be brought to the surface, "What is it?" The emotional outbursts, want of control, tantrums, excitements or rages, must be made not worth while. All unwanted habits must be deprived of any content which gives satisfaction, and have attached to them conditions to make them unpleasant, whether it be black marks, loss of distinction, or simple want of notice; they will be then likely to be slowly eradicated for more healthy conditioned reflexes in working.

This, it will be urged, is the mere reward and punishment, but no physical punishment is allowable where the unpredictable reaction may be violent. In any case, punishment that is not completely and fully realized by the child as a result of a definite cause is wasted, if not actually injurious.

Punishment of any violent kind must be unobtrusively witheld from the psychopathic child. The real educator is the one who can set a high aim before the child, who learns from the Boy Scout's gospel of one good deed a day. If some definite aim and purpose is instilled, then the child's nervous system will make its own subconscious arrangements, more perfect than any teaching art can do; it will educate itself by functioning towards the mark set before it; it will develop character and grow in grace.

These various groups overlap or run into each other to such an extent that it is the best for the examiner to treat each case as *sui generis*. Later he will not be able to avoid grouping them under headings almost from the first contact. In the Jewish Hospital at Cincinnati a Psychopathic Institute has been established where a child is taken in and thoroughly studied over some weeks. Such an institution was advocated for London nearly twenty years ago, but the School Authority did not adopt the suggestion. It is far the simplest approach, and will soon lead to decisions not only of particular cases, but also of general questions.

At Cincinnati they now class the cases which display abnormal conduct under four general headings:

The Personality Group, much the largest and embracing most of those already described as unstable.

The Endocrine Group, where various ductless glands are supposed to affect conduct; purely medical cases.

The Organic Group, when diseases, or their results, as in the case of Congenital Syphilis or Polioencephalitis, may be diagnosed; also a group of medical cases.

The Mentally Defective Group, which will be dealt with later.

During 1924 some 37,000 children in the schools of Greater New

York were reported by the educational superintendents as in need of psychological service (*J.A.M.A.*, 1925. i. 1504). It is here that a new specialist in the visiting teacher is useful, trained in the ways of psychological approach to these children's problems.

Exceptional and Superior Children.—The average mentality of unstable children may coincide with normality. In some directions they fall short, in other directions probably exceed it. The 90–100 percentiles of intelligence groupings are mostly precocious, and some of these of the unstable groups are numbered amongst them.

On a previous page the proportion of pupils worthy of education qualitatively on a higher plane than the primary school has been estimated as 12·5 per cent., but probably not more than a quarter of these have that all-round excellence which would anywhere distinguish them as superior.

Irregular possibilities of high development in one or two directions may occur in others who are far below the general average. The "Katzenraphael" Gottfried Mind (1768–1814), whose pictures are seen in galleries of Central Europe, was a woodcarver who could not write his name, and remained mentally a cretinous child. There are many musical and arithmetical prodigies of the same type as the *idiot savant* in institutions—boys, for instance, who can tell the exact day of the week on any date for centuries back. The same extravagant development may occur in an otherwise quite normal person. "When almost 6 years of age, Ben was walking with his father before breakfast, he said, 'Papa, at what time was I born?' He was told 4 a.m., and then he asked, 'What o'clock is it now?' He was told 7·50 a.m. After walking about a hundred yards he turned to his father and stated the number of seconds he had lived. The father noted the figures, and reckoned them out at home, and told Ben that he was 172,800 seconds wrong, to which he got the reply, 'Oh! Papa, you have forgotten the two leap years,' which was the case, although the extra day for leap year is not usually known to children of six" (*Proc. Soc. Phys. Research*, viii. 352). The future of this boy apparently was unremarkable.

Inaudi, who could extract the cube root of nine figures, the fifteenth root of twelve figures, and so on, was otherwise normal, but could not repeat more than five or six letters. Binet describes his memory for figures as at least a hundred times the normal, and it was entirely auditory and motor. He listened to the problem, and dictated the answer, which an assistant wrote down on a blackboard. Diamandi, a Greek merchant, whose brother and sister had a similar aptitude, spoke seven languages, and had a wonderful visual memory for all things. A square table of figures, which Inaudi could only repeat in the order in which he heard them, Diamandi could repeat in any order. Neither of them knew anything of higher mathematics (*Rev. Psychol.*, i. 10).

On the other hand, Professor Safford, who at the age of 10 could work mentally in one minute a multiplication sum whose answer ran to thirty-six figures, lost this faculty as he grew up.

As a boy the memory of James Hinton was marvellous. A schoolfellow of his at Reading recalls that when the master set six pages of history, Hinton read it once and repeated it verbatim. But rushing one day hurriedly from cricket to his lessons, there was a sudden lapse of his exceptional power, a sense of goneness, and it never returned to him (Sir J. C. Browne).

Mathematical capacity is not related to arithmetical in a very direct way. The calculators were nothing as mathematicians, whilst Lord Kelvin's mistakes on the blackboard used to daily prove the converse to his students. A test one may try on themselves, is raising 2^x mentally. It seems a good test of fatigue, and is an amusement if one is confined to bed. The x varying in my own case from 14 to about 19 under different circumstances, with 16 or 17 as the average. After six figures are reached it is difficult to hold them in mind. Probably many would manage seven, eight, or a dozen, and Inaudi would have reached something unbelievable.

There are many infant prodigies of whom one hears no more. A few years ago the education and precocious accomplishments of the son of a noted psychologist were a world wonder, but he was last heard of at the age of 25, clerking for a paltry weekly wage. Similar cases will be known to many.

A prodigy, mentioned as such in *Evelyn's Diary*, became an F.R.S., after he had taken his degree at Cambridge with the note in the Register, "*In Gulielum Wootonum stupendi ingenii et incomparabilis spei puerorum vixdum duodecim annorum.*" He was then acquainted with twelve languages, but his career was not phenomenal. A later recorder notes that "doubtless it would have been more crowned with wordly success had it not been that he was extremely thriftless, and somewhat of a gay Lothario."

Precocity does not necessarily connote good or excellent conduct. Still quotes the case of a precocious boy who could read and recite at the age of 3, but his next twelve years is one long story of stealing, lying, lack of natural affection, indecency, sexual immorality, and an attempt at suicide (*Boston M. & S.J.*, 1888. 537).

The "Admirable Crichtons" have generally amassed stores of learning from possession of a superb memory for symbols, and few have done much with their learning. They are probably generally ordinary individuals with this talent and without the capacity to utilize it to add to the human stock of knowledge. Racial precocity with children may also come in. It undoubtedly gives the young Jews of London far beyond their share of educa-

tional awards, which a proper method of assessment would considerably alter.

The majority of precocious children, including the miserable imitative specimens forced by fond parents, and often only children, sink back to average with adolescence. The same happens with the Wunderkinder in most cases, and Sakaki notes that in Japan they are often early suicides. The record child is Christian Heinecken of Lubeck (1721–24), who knew most of the Bible by 12 months, and the whole at 14 months. He was not weaned until a few weeks before his death, and on his death-bed, aged 4, "displayed the utmost firmness and resignation."

These have been quoted to shew what extreme variations are possible. Real genius is often precocious. Examples are abundant. Physicists, mathematicians, writers, musicians, artists, engravers—they crowd into one's memory. Dr. Leonard Guthrie dealt chiefly with this class and the *intellectus universalis* in the Fitzpatrick Lectures (*Lancet*, 1907. ii. 1592).

One of the most illustrative in precocity and productiveness was Dr. Thomas Young (1774–1829), the Physician to St. George's Hospital, who established the interpretation of the hieroglyphics, discovered the accommodation of the eye, and propounded the undulatory theory of light. He could read at the age of 2, and by 4 had read the Bible through twice.

Wise are the words of Sir James Crichton Browne: "Happy the child who is neither backward nor forward, but in the golden mean, who slowly and steadily climbs to the summit of its powers, and can with rude health, a clear head, and an even temper encounter all the chances and changes of this troublesome world."

Yet it is in those with high mentality that the hopes of humanity must lie. Obviously, there are great differences in the intelligence, both quantitative and qualitative, of these superior children. In school their capacity is even underestimated. A teacher assessing children mentally in one of my earliest enquiries, put down two girls, both in Standard III, as "poor" and "very good." The "very good" was a tall, "flabby" girl of 11, the "poor" a little freckled, half-starved child, $8\frac{1}{4}$ years old.

Terman found that bright children were generally located below their proper level, and the brighter the child, the worse the error. He found that no one of the children with I.Q. = 130 or over had had any special home care, their parents were unaware of their capacities, and he thought school rather a deterrent to them than a help. Compared with the possibilities, he thought the child of exceptionally superior intelligence almost always retarded. Yet such a child gets time to think and grow, in a way the ordinary child lacks. Whilst the superior child may not get a chance of his possibilities in the primary school, to others he may be rather a

hindrance, and discourage the slow striver. On the other hand, school is tedious to him; the utter boredom of a reading lesson may be almost intolerable, and is relieved by loafing or devising mischief. Group tests would readily separate them. On economical as well as educational reasons the three sets of superior, ordinary, and subnormal should, through group testing, be selected by eight or nine years, and any deficiencies of intelligence ratings fully adjusted by the educational touchstone ere 10 or 11 years of age.

These all-round superior pupils are not likely to be overworked. Garrison and Pullias, in Nashville, demonstrated that there is definitely correlation between physique and intelligence. Of their 90–10 percentile intelligence groups 76 per cent. were above the 70 percentile for physique. They found the highest correlation was shewn between strength of grip and intelligence rating (*Psychol. Clinic*, 1923. 259).

Our present classical education with its artificial conventionality is mainly memory work and verbalism, and would be the most damning thing to intelligence were it not that the middle-class child of superior mentality is generally able to pick up here and there information and develop his stock of real knowledge from out-of-school sources.

The next move in education almost necessitated by physiological considerations is the provision of problem classes, "A" classes, or classes with some such inoffensive name, for the supernormals, who could study all their subjects intensively and thoroughly and for the sake of their fellows get an education suited to their abilities.

CHAPTER XX

SEX EDUCATION

A FRUITFUL cause of trouble, not so obvious in earlier years, is the adjustment of the individuality in respect of sex.

Sex is one of the primary and oldest established functions. It has been carried on for millions of years and needs no education. Where sex and social arrangements cause interference with normal life activities, it is unlikely that sex is at fault; much more likely that the later developed and artificial social arrangements are in error.

Civilization requires certain arrangements for convenience, but Nature does not call for these. Celibacy or chastity are immature conditions, not natural qualities; they are purely artificial ideals, useful in a degree, but capable of becoming harmful and destructive.

The individual reaction is almost entirely a matter of emotions and endocrine constitution. No intellectual training can be trusted against temperamental make-up. The mental conflicts arising from artificial suppression without proper sublimation of the fundamental instinct lead to any of the troubles already outlined. The results of these conflicts may eventuate in all kinds of ways. Some of the detritus are the futile inhabitants of convents, monasteries, or madhouses—waste products so far as Nature is concerned.

Much of the depths of depravity unearthed by schoolmistresses from juvenile proceedings are merely natural actions resulting from observation or curiosity. They are usually but slight evidences of moral value so far as the child is concerned, and are grown out of.

Either boys or girls may have bad habits which will disappear if they are not stereotyped by educational means tried for cure. It is only in defectives that they are likely to be pathological.

A secret enquiry, among over 5000 well-educated American women (*J.A.M.A.*, 1925. ii. 1113), gave the results depicted on the diagram. The curves I, II, III, IV, representing age beginning of autoeroticism, puberty, marriage and menopause respectively. Autoeroticism has to be treated as a bad habit and of the same moral turpitude as wetting the bed.

There is an enormous amount of foolish sentimentality about sexual things. They are combined in discussions with talk about

their beauty and sacredness, which is exactly the beauty in any other organic function combined with instinct, and rings false to the child.

Religion and religious ideas have done untold damage to human lives by this taboo placed on things sexual. For the regulation of society it is not instruction in sexual processes that is needed, but instruction in the conventions and manners of society regarding them. Apart from this, the saving knowledge that will prevent conflicts arising in the child's mind can only come by the removal of the conspiracy of silence so prevalent regarding Nature's methods.

Information of the needed kind cannot be taught in school classes. Either it would not be understood, or it would do harm

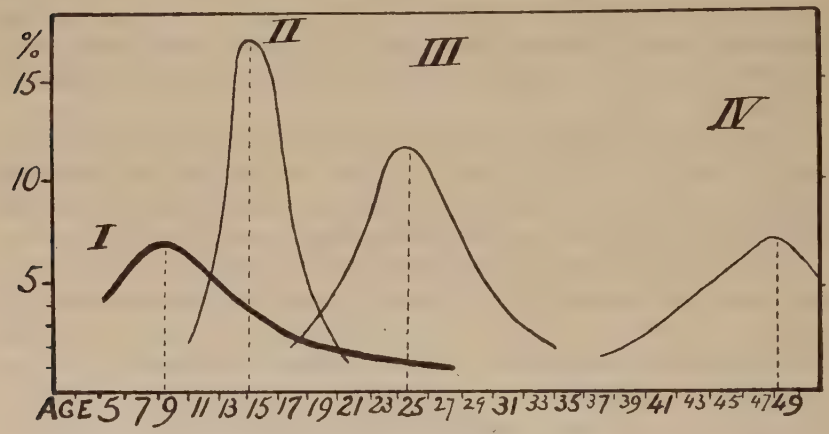


FIG. 81.—ONSET OF EVENTS IN AGE HISTORIES OF 5000 WELL-EDUCATED AMERICAN WOMEN.

I, Autoerotic; II, menstruation; III, marriage; IV, menopause.

or come too late. The only reasonable way is to make the information accessible and evident to all, so common that none can miss it. A plain scientific statement of facts, uncombined with sentimental or emotional context, would be gradually built into the child's subconsciousness for use when wanted. The immature would pass it unnoticed, yet it would sink in subconsciously and the mature would have the knowledge ready for service. This can best be done, apart from individuals, by having the information scattered in text-books, dictionaries, cyclopædias and all kinds of reference books. It should never be suppressed anywhere. That is the only solution the writer has to suggest.

After having arrived at this position, from an entirely different approach, it is found to coincide almost completely with the teaching of the psychoanalytic philosophy of Freud (*Social Med. u. Hyg.*, 11.

No. 6), who thinks that in sexual matters at no time should anything be treated as hidden or secret, but always as an ordinary matter to be spoken about from the first. Then the child will never have any undue curiosity.

If this process is followed, the troubles that are now found among adolescents would scarcely ever arise. Neither boys nor girls would be distracted by the onset of puberty, and life later would have considerably increased values for all.

CHAPTER XXI

SUBNORMAL INTELLIGENCE

Turning to subnormal groups selected by school position or from intelligence gradings, about one-eighth of children are found to drift behind steadily through school life. They are unable to keep up with the stream, as school conditions are too hard for them. These may be considered subnormal children.

Probably if tested by refined methods, more abstract ideas and combinations would be found beyond reach, but simpler affairs of life within grasp. In the life of a village these children may pass almost unnoticed, but in intricate city life they fail to maintain their position. They have been described as dull normals. They cannot be normal when in such matters as reading and writing many are failures. In after-life some lose the modest accomplishment of school to such an extent that ten years later they cannot read test types, having forgotten most letters.

From this class of social failure come many stupid delinquents. Ordinary school education is not only wasted on these children, but it prevents them, during the only period they are likely to benefit, obtaining the education which they are fitted to receive. They require to be discriminated not later than 8 to 9 years of age, for the purpose of training by sensory experiences and kinæsthetic means. Ordinary school is to them a barren treadmill of things whose meanings they cannot understand.

The Intermediate or Fourth Standard School, or parallel classes on the Oakland plan, with quite low aims, plenty of coarse manual training, and exercises, seems logical education on which to spend money or expect results equivalent to the capacity of the children. Below their level come children so obviously incapable in school that many authorities had set up special educational care for them, years before State provision.

In 1894, before the days of intelligence scales, the number of children who ought to be removed from the ordinary schools in Bradford was estimated by the writer as 2 per cent. of the school population. This was after a survey extending over several months. In 1905 Binet assigned the same number among Parisian scholars. Education Authorities in this country would take half that number as sufficient, and the Royal Commission in 1908 estimated 0·86 per

cent. The United States Bureau of Education in 1911 estimated 4·0 per cent. of the school population as feeble-minded, and one-eighth of these of grade needing institutional care. In 1915 Dr. Williams returned 3·2 per cent. of the scholars of Salt Lake City as feeble-minded. These figures shew 10 to 20 per thousand children come into the category, and the original estimate of 2 per cent. will probably be the ultimate provision.

These are children who would be placed at the lower end of the curve on page 358—the mentally defective. In America this whole group is called feeble-minded, and includes imbeciles and idiots. In England these last two groups are excluded, and feeble-minded is usually taken as mentally defective who are not idiotic or imbecile. For the group thus restricted Goddard in 1908 introduced the term "moron," from the Greek word μωρός, for a fool. The word was used by Molière in one of his plays, in a part which he took himself, of Moron, a Court fool. The term is to be recommended as avoiding any ambiguity, and also for the laity as being without emotional content. American workers probably include some under the term whom our authorities would have kept in the ordinary school as dull-normal children. They would come into the 2 per cent. class of defectives. The earliest educational selection of defectives made in England was the result of a few enlightened school boards segregating these children in special classes. The first statutory recognition was based entirely on educational grounds.

The Elementary Education (Defective and Epileptic) Act, 1899, where adopted, provided for these children. Now in the Act of 1921 this has become a duty required, to select those who "not being imbecile, and not being merely dull or backward, are defective; that is to say, what children by reason of mental or physical defect are incapable of receiving proper benefit from the instruction in the ordinary public elementary schools, but are not incapable by reason of that defect of receiving benefit from instruction in such classes or schools as under this part of this Act may be provided for defective children."

Although a lawyer might object to the vagueness of the terms, this definition conveys the sense fairly. It is purely an educational selection. The limits are imbecility below, and fitness to properly benefit by the ordinary school above.

The lower limit soon gave trouble. Children excluded under this Act as unfit for special schools were thereupon educationally classed as imbecile. Their further care should have fallen upon the Poor Law Authorities. These refused to make provision for most cases, holding them as not imbecile. Where provision was made the Authorities insisted on parents or guardians becoming paupers, even when the whole cost of care was borne by such persons (*L.C.C., M.O. Ed.*, 1908. 1). A Royal Commission dealing with this brought

about the establishment of the Board of Control. This Commission drew the line of normality in rather vague phrases, amended in the Mental Deficiency Act of 1913, but making efficient citizenship the test.

The ground of selection is that alleged defect must be deemed congenital and affect social efficiency.

Binet made a classification based on the use of speech; idiots did not use words coherently, imbeciles used words, but not coherent sentences, whilst the feeble-minded (morons) could use ordinary speech.

The American Association for the Study of the Feeble-minded defines the classes in terms of mental ages which correspond roughly to Binet's speech classification, idiots being those with mental age up to II, imbeciles from II to VII, and morons (the English feeble-minded) from VII to XII.

With idiots and imbeciles we are not concerned, save that the school doctor must be prepared to judge what child is ineducable. In any case of difference of opinion, or where his judgment is contested, the final decision would be with the Board of Education. Their official Report sets out a reasoned diagnosis of mental deficiency which should be stated, but of which it is difficult to grasp any meaning.

Their theory of mental deficiency is—

188.—For the moment we are concerned with the psychological manifestation, and it is here necessary to state that no diagnosis of mental deficiency is safe or acceptable which is not expressed in terms of definite memory absence. The variety of mental conditions exhibited by mentally defectives is wide, and affects every aspect of judgment, questions, action, and "attention to life." If we probe the problem to the bottom we shall be able to refer the whole of these conditions to the absence or defect of memory power. The study of mental defect in this sense is, in fact, the study of memory power. Absence or impairment of memory power is the one quality which all mentally defectives hold in common, and with which all other psychological manifestations are related. A child who cannot remember has nothing to store—he has not the mental material to enable him to contrast or compare, and thence to form a proper judgment whether in visual or abstract imagery. Consequently his emotions fail in their proper setting, and his "direction towards" life, his volition, his actions, language, and movements suffer. He becomes, in fact, "incapable of managing his own affairs," and for the basic reason that his memory power is imperfect (*Report of the Chief Medical Officer of the Board of Education*, 1920. 107).

There is more useful stuff for the affairs of life in the Mental Deficiency Act, 1913—

Section 1.—The following classes of persons who are mentally defective shall be deemed to be defectives within the meaning of this Act—

(*a*) Idiots, that is to say, persons so deeply defective in mind from birth

or from an early age as to be unable to guard themselves against common physical dangers.

(*b*) Imbeciles, that is to say, persons in whose case there exists from birth or from an early age mental defectiveness not amounting to idiocy, yet so pronounced that they are incapable of managing themselves or their affairs, or, in the case of children, of being taught to do so.

(*c*) Feedle-minded persons, that is to say, persons in whose case there exists from birth or from an early age mental defectiveness not amounting to imbecility, yet so pronounced that they require care, supervision, and control for their own protection or for the protection of others, or, in the case of children, that they, by reason of such defectiveness appear to be permanently incapable or receiving proper benefit from the instruction in ordinary schools.

(*d*) Moral imbeciles, that is to say, persons who from an early age display some permanent mental defect, coupled with strong vicious or criminal propensities, on which punishment has had little or no deterrent effect.

Educational Legislation concerning Feeble-minded.—The original Education Act of 1899 was permissive, but in 1914 the duty of educational provision for the mentally defective was made obligatory, and this, with the duties of the Education Authority under the Mental Deficiency Act, 1913, is restated in the Provisions of the Education Act, 1921.

Section 53 extends the duty of a parent in the case of any defective or epileptic child over 7 years old, to cause his child to attend to receive efficient elementary instruction in any place where there is a special class or school certified by the Board of Education, and need for a guide or conveyance does not abrogate this duty.

Under Section 55, the Local Education Authority must make arrangements to ascertain what children in their area should be educated as mentally defective, and what children being epileptic, but not idiot or imbecile, are unfit on this account to attend the public elementary schools.

For this purpose, in regard to any child, a certificate is required from a duly qualified medical practitioner approved by the Board of Education. The certificate has to be in a form prescribed by the Board (p. 389) and the doctor, if so directed by the Local Education Authority or required by the parent, before giving the certificate, must consult the head teacher of any school which the child has been attending, or such other person as the authority directs, and a copy of any report they make has to go to the Authority. In any case of doubt as to the mental status of the child the matter shall be determined by the Board of Education.

The Local Education Authority have also duties of notifying to the Local Authority, under the Mental Deficiency Act, 1913, any defective child over the age of seven who

(*a*) Is not capable of benefiting from education in special schools.

(*b*) Who cannot be instructed in special schools without detriment to the other children.

(*c*) Those certified by the Board of Education to require supervision or guardianship under the Mental Deficiency Act.

(*d*) Those who, after leaving the special school, need Institutional treatment or guardianship.

Section 61 extends the period of compulsory education for mentally defective children to 16 years of age.

Where it is proposed to notify the name of a child who is not an idiot or imbecile, or where the defect is, combined with blindness or deafness, within the meaning of the Elementary Education Acts, the L.E.A. has to furnish a copy report of the certifying officer to the Board of Education, and receive their consent before the name is notified.

Who are Mentally Defective?—To ask who are mentally defective is like asking who are dwarfs—the typical cases are clear, but the dividing line indefinite. The normal shades into undoubtedly defective with a broad band of border-line cases. Most of these falling on this border can be stated by a careful observer as not of normal intelligence, but he can also assert that they are not mentally defective.

There is physiological variation, both quantitative and qualitative, in mental capacity. By any method of assessment the majority of cases will distribute themselves about a normal in accord with the ordinary curve of error. Simple amentia generally means this physiological poverty of capacity. A considerable group do not follow this distribution but are near the lowest end of the curve. They are made up of varieties of amentia, constituted by pathological feeble-mindedness associated with syphilis, epilepsy, hookworm, and such assignable causes. This diagrammatic mode of representation helps us to orient ourselves in considering these cases, but as yet is not of practical avail in classification of individuals.

The phrase "pathological feeble-mindedness associated with syphilis" does not indicate that syphilis is a great cause of amentia. The Wasserman test in over 9000 mentally defective in America shewed 5·4 per cent. positive, whilst 16,000 non-defective controls shewed 4·3 per cent. Of 1756 defectives in Wrentham only 60 shewed positive Wasserman, and only 30 of these could reasonably be assigned as due to syphilis (*Boston M. & S.J.*, 1925 ii. 668). Mental defect is more likely a cause of congenital syphilis than congenital syphilis a cause of mental defect.

Binet and Simon devised their scale for the purpose of classification, but guarded themselves carefully in stating that its indications would only be part evidence on which a diagnosis of feeble-mindedness should be based.

The Vineland workers industriously applied it to both normal and subnormal groups, and at first took two years' retardation for cases below the age of 9, and three years for those above this age,

as the amount of defect marking this upper limit of feeble-mindedness. Later they took for post-adolescents a limiting mental age between XI and XII.

This XI to XII represented the upper limit of moronity, as they called it. This limit was reduced gradually by various workers to X or IX as originally proposed by W. Stern. The intelligence quotient when introduced gave a more rational statement, and better gradation ; retardation could then be expressed by this quotient.

Terman, using his revised Stanford Scale, made a classification which may be adopted as follows—

Table 58.

Low-grade amentia :	Idiots	Approximate I.Q.	–25
	Imbeciles	Ineducable	25–50
High-grade amentia :	Mentally defective	Morons	50–70
		Border-line	70–80
Normal		Dull	80–90
		Average	90–110
		Good	110–120
Super-normal		Excellent	120–140
		Super-excellent	140–

The experience of life, in the assessments of the Division of Psychology of the U.S. Army, shewed masses of men with intelligence levels of VIII to IX comfortably supporting families by their work, and coal-miners were found who could not pass the VII level. The intellectual level of 7·8 was taken as the limit of unfitness for Army work. From 7·8 to 10·2 were put in service corps, and 10·2 years mental level or over in the regular Army.

The more closely the feeble-minded are reviewed the more does the necessity appear for the Fourth Standard or Intermediate Schools proposed in London twenty years ago. It is not fair to a child with I.Q. 80 or more to maroon it in a special class. It is retarded in mentality, and yet is likely to become a self-supporting citizen if properly educated within its limits. It is equally wrong to leave such a child to drift hopelessly, accentuate any feelings of inferiority, or push it towards delinquency, by leaving it in the ordinary school.

The defective and normal child of the same intelligence levels, that is equal mental ages, differ. Whilst the normal has considerable potentiality of mental growth, the defective, especially if he has nearly reached his mental limit, has very little or perhaps almost no such potentiality. The defective being older has greater experience and better physiological growth, and generally has better motor accomplishments, but if tested on simple repetition tasks the practice

improvement curves are similar in both and equally good (Woodrow, *J. Ed. Psy.*, 1917. 85). The power to gain by practice means formation of conditioned reflexes in certain neuronic arcs, which are in existence. It differs from the power to learn, which means linking up of numerous new series of arcs, and in the defective some of these may be wanting. The defective always is defective, whatever his age.

Statutory Examinations.—The chief source of these children for examination is the ordinary school. Teachers have to select children whom they deem suitable for education in special schools. Teachers' opinions are very varied. This variation comes out strongly where the teachers are left to submit children for examination as being mentally defective. Some submit low-grade cases, whilst others select batches of which not a quarter are more than a little backward. Teachers may be asked to make lists of all who are school retarded more than two years. Here again, for instance, one has found a great girl in Standard V who could not read, merely there because too big to remain among the little ones. The lists are usually submitted to the school doctor for inspection. He makes a physical examination, or at any rate sees that the child's school card has definite note as to visual acuity, hearing, throat conditions, physique, or nutrition. In London a proposal form is filled in by the teacher giving general details as to the child, also answers questions about temper (obedient, mischievous, or spiteful) ; cleanly habits ; capacity in reading, writing, memory, calculation, drawing, and rhythm. The child is then submitted for statutory examination. An admission card to the examination being sent home, when the appointment is made for child and parent to attend. Attendance is compulsory under penalty. The teacher, too, attends with school records of the child. As a matter of arithmetic, in applying the Intelligence Scale Tests, the younger the child the more difficult is it to assign it finally to a particular group. When it is anywhere near a border-line the safest course will be to make an interim report, until further clinical opportunities enable final decision.

A child of $5\frac{1}{2}$, having been seen on previous occasions, was adjudged a harmless high-grade imbecile. He remained in the infant school, but it took two years to ascertain that he was intelligent, but suffering from a condition of congenital word-deafness, not previously described. After this he made good progress and was taught to speak (*Lancet*, 1900. i. 446).

In doubtful cases, accessory maze tests of Porteus, and Healy or other form-board tests will be useful. The difficulties are not with the candidates for special school admission where a judgment can be suspended or reviewed, except that it is inadvisable to have to withdraw a certificate if this can be avoided. The medical examiner must be able to furnish a certificate and, if necessary,

support it with evidence that the child is incapable of receiving proper benefit from instruction in an ordinary school. The real difficulty arises where the doctor has to decide at once whether a child shall be reported to come under the Mental Deficiency Act as requiring Institutional or other treatment.

Heredity is of some importance, but the time at disposal scarcely allows its investigation as ordinary routine. A mother, herself in attendance, is often obviously mentally defective. In one case my enquiry as to what the child's father was like met the astonishing reply from an apparently sensible married woman: "How could I tell who his father was." The past history of the child is of first-class value, for the definition "from an early age" has to be satisfied, and all intercurrent mental conditions must be excluded, except in so far as they are superadded to an underlying condition of feeble-mindedness. It may be noted that the Definitions in the 1913 Act are extended specially in the case of children; except Moral Imbeciles who are "persons," and presumably children of this class are only included by the implication "from an early age." Magistrates sometimes cause trouble over this phrase about an early age, and, where parents or guardians are dead, it may be difficult to satisfy them. The Tasmanian Mental Deficiency Act has provided a clause that "such evidence shall not be considered absolutely necessary for determining whether an alleged defective is a defective within the meaning of this Act." Personally, the writer would sign a certificate "from an early age" for any age within the developmental period.

Parents, beyond perhaps acknowledging that the child cannot be trusted, minimize many slighter cases. School attendance officers sometimes contribute valuable facts as to family and personal history.

Care committees and social workers are prone to emotional and exaggerated views, and frequently assume faults that do not exist. "There is no evidence that the parents are not married" is the kind of note encountered.

The conduct and general behaviour of the child at examination needs a descriptive note extending to several words. Gestures, postures, attitudes, and tricks should be recorded. A child's want of realization of its position, lack of respect, inordinate curiosity, sometimes quite brazen and unabashed behaviour, are characteristic in some types; others are silent, sullen, or fearful. Records from school or home may refer to cruelty, destructiveness, passionate outbursts, biting or pinching others, and neglect of personal cleanliness. Record at the time of mental examination the actual attainments of the child in reading, counting, copying, or drawing, as concrete facts which have to be quoted later. The older the child the less important are these matters in judging fitness for social

efficiency. Various stigmata of degeneration should be noted, although of scanty value for judgment.

Defect as measured by Intelligence Scales might appear increased in relation to social efficiency, if there was any way of measuring the temperamental or emotional reactions, or the moral level of the individual. These can be only roughly judged from behaviour, (i) either observed at time of the examination, or (ii) as stated by others. These two distinctions should be drawn in record.

The duty of the L.E.A. is to ascertain which children between 7 and 16 are educable in special schools. The ineducable have therefore to be judged, to notify them to the Local Control Authority. Where the intelligence quotient is below 50 the child is almost ineducable for school purposes, and should be carefully observed for a time. If it has manual incapacity, or is wanting in energy and purpose in life, very short observation is needed for the decision.

The legal definition of unsuitability for education under the Act of 1913 is that the child shall be "permanently" incapable of receiving proper benefit. If the child is excluded from school as ineducable then it falls into the imbecile class defined as "one who cannot be taught to manage himself and his affairs." There must be doubtful cases among the younger children, and those below 7 years do not count under the Act. There are also cases where past history makes it evident that the child will be hopeless in a special class, but the examiner himself may as yet see no evidence of this. He should put the child into the special class for observation; making this almost the rule with those below 8 years of age, not obviously imbecile. No child over 7 gains from being returned to an infant school, to be kept among younger children.

The cases sent to special schools for observation and report are best reviewed in three months. The parent has the right to apply for re-examination at intervals of six months.

The low-grade child who has not reached its final mental level shews slow improvement in class at first, but there is probably arrest in progress in a year or two. Once this is determined, and the child has come to a practical standstill, it is wasteful to have it filling a costly place, with more suitable candidates excluded for want of room. Even those who are learning a little may include some who are obviously incapable of managing themselves, and irresponsible in behaviour. Exclusion turns on inefficiency in life rather than incapacity for school-work. If behaviour is irresponsible, irregular, and uncontrolled, and does not improve, and with this, attention cannot be fixed, and the child does not profit by its mistakes, it must be relegated to the ineducable category of imbecility.

There is a prescribed statutory form of certificate, to be filled in which runs :

I, ..., a duly qualified practitioner, approved by the Board of Education, certify that the above-named child, not being imbecile and not being merely dull and backward, is, by reason of (1) mental or (2) physical defect, incapable of receiving proper benefit from the instruction in an ordinary Public Elementary School, but is not incapable, by reason of such defect, of receiving benefit from instruction in a Certified Special Class or School.

Signed.....
Qualification.....

These special school children, after a period of school work, can be tentatively classed according to their likely educational fate as—

1. Children who are making no reasonable progress and are ineducable, and so reported to the Local Authority under the Board of Control—a Mental Deficiency Committee—during their school age.

2. Children who make some continuous progress, but who obviously will not make their own way in the world, nor earn a living. They must be dependents, and before the age of 16 should be reported to the Local Authority Control, for Institutional Treatment or Guardianship.

3. Those who made sufficient progress to suggest that they will be able to manage for themselves in some humble way. They require after-care for a time, as their later history is rarely equal to school expectations.

4. A few who generally may be taken as cases where the diagnosis was doubtful. They progress possibly well in other than academic subjects. If they can do work of Standard II by the age of 12, transfer to ordinary school should be considered, but if there are Special Schools for elder boys or elder girls these will be more suitable. Each case here requires separate consideration according to further scholastic provision possible.

For defective children who are reported to the Board of Education, certain prescribed forms have to be filled up, unless the case comes under the heading of idiot, imbecile, or moral imbecile, if not blind or deaf. Cases under these headings may be notified directly to mental deficiency committees. Other cases can only be legally notified after having been certified on these forms to the Board of Education.

The forms now (1925) required are too long to detail. Form 41D is a report by the head teacher to be completed in the case of educationally retarded children as a preliminary to their examination by a certifying officer under Section 51 of the Education Act, 1921, or Section 31 of the Mental Deficiency Act, 1913.

It includes details for the identification of the child, and scholastic tests for the three R's, and a statement of drawing and manual work, and of its behaviour, disposition, and home environment.

The present (1925) Form 306M is a comprehensive record of physical examination, environment, history, temperament, response to environment and school instruction, intelligence tests and general observations, diagnosis and treatment. For administrative purposes the only items of this form necessary in all cases are (i) identification, (ii) nature of defect, (iii) intelligence quotient, (iv) treatment recommended, (v) signature.

Form 306M extends to four foolscap pages with instructions to add

sheets for various educational examples, and different types of intelligence tests. It would require from one and a half to two hours to fill up. As a practical administrative instrument, for all cases, it is a piece of red tape of little use to the community and adding expense to educational work. It is also a reduplication of work the utility of which is not evident. The mass of detail sent into the Board of Education in this way means increase of staff at both ends, without useful purpose.

Reference, of various kinds and innumerable varieties of educational details, by Authorities to the Board of Education has been a constant drag for years on activities, and usually leads to a tedious and often perfunctory repetition of work and reports by another set of inspectors, who have to justify themselves in a set of petty criticisms usually of no importance, and as often as not meaningless, but involving more criticism and discussion at length. This applies not only to these forms F, but to all kinds of educational administrative and constructive work.

Special School-work and Tasks.—When children are in special schools they have to be medically inspected at intervals of not more than 12 months. At each examination, general health, vision, hearing, and speech must always be noted. Conduct, emotional conditions, the three R's, and manual work are to be remembered. A note is to be made of any intelligence tests applied, and a remark as to any out-of-school knowledge, or possible change in the mental age.

The purpose of school is to make the child an efficient citizen, self-supporting and self-respecting, or if, as in most cases, that is not obtainable, then as little dependent as can be achieved.

Academic ideals of many teachers make them struggle bravely, but uselessly, to teach the children things for which the majority are mentally unfitted.

The main purpose of school should be to find out any useful thing that a pupil can do effectively, and teach him that. Their school accomplishment in any line will probably be far beyond that of out-of-school work. As they get nearer 16 school-work counts for less and less, and some useful if humble accomplishment for more and more, if it helps them to float in the community.

Their learning should be attained by imitation and repetition. How to do, not why to do, is the purpose of the special school. It is not worth while explaining principles of work to children who have no real conception of what the teacher is talking about.

Can something be done to find a way to evolve functioning from higher neurons ? If it is possible to set out some kind of aim or ideal to reach, and to give some feeling of responsibility, this will be done.

All the cleansing, polishing, and attendance to the domestic duties of the class should be parted out among the children, according to

their abilities. If the child takes a pride in his work, he is being morally raised.

To spell three- or four-letter words seems a futile result for years of toil and teaching, and even that will not be reached by those with I.Q. below 70. The child who can learn to read usefully should be in a Fourth Standard or Intermediate school. His mentality will be over the mental age of nine years. The making of letters, and attempts at spelling, should only be regarded as an amusement, not a serious study for children in special schools.

Writing depends on knowing the letters, and writing the simple script forms has a value in training finger movements and the use of the hands.

Speech training is often neglected. Twenty years ago the articulation of London special school children was slovenly and bad. The superintendent (Mrs. Burgwin) took this in hand, with the result that in a few months it had improved so that the speech of the special class children was superior to that of the same mental level in the ordinary schools. Without constant attention it is unlikely that this has been kept up. Imitative speech is a possession of the very young child, and the quality of articulation is the best evidence of good teaching in these classes. On this articulation, and on the posture of the children, the doctor can base his impression of the school. Again, unless watched and trained, about half the mentally defective acquire the mouth breathing habit and expression before their school age is past.

Physical training, posture, gait, and good habits of breathing are more to these children, in regard to their acceptance in life, than any knowledge of the three R's that can be given them.

Whether it is mouth breathing or merely want of attention, many of the mentally defective do not seem to hear well. Children who are intelligent but hard of hearing from an early age are often taken for mentally defective. The extreme case of the hearing boy, word deaf, and for three years classed as imbecile by the writer, has been mentioned.

Habits have to be formed, conditioned reflexes, the result of continued repeated operations. Primitive appeals, religious or otherwise, to primitive emotions ; simple concrete actions done as shewn or told without reasons or detailed explanations are best. The arithmetic involved in money transactions, necessary to purchase a pound of sugar, an ounce of tea or a loaf, is about their useful limit.

Arithmetic on paper is quite useless work in the special schools. It may be obtained in a mechanical way by aid of strokes or counting fingers, but it is of no practical use and will be forgotten in a month or two. Any operation of this kind which can be performed mechanically, but needs intelligent thinking or planning to become useful, is one of the spurious results which are so common in our educational

system. Sewing or darning, brush-making, mat-weaving, or perhaps cobbling, various domestic tasks, are all things which are utilizable in later life. At carpentry they never become good enough for it to be other than a recreation. Basket-work is merely a useless pastime with nearly all, and after a little time to train fingers should be left off, being valueless as an asset later.

The observation of the mentally defective is usually very poor. Tested by the methods of the psychological laboratory, the defects of the normal child are pronounced, but when slightly defective (*Leicht Schwachsinnige*) children were tested their evidence in all respects as to numbers, colours, events or persons was unreliable, and they were easily affected by suggestion (*Eos*, 1907. 81).

Classification of Mentally Defective.—The classification, so far, has been based on intelligence, but there are various types under which the subnormal child may be ranged.

The results of over 8000 children admitted to the special schools, and 5000 certified under the Mental Deficiency Act in London, are given by Shrubsall as follows, in percentage—

Table 59.

	8000 Suitable for Special Schools.	5000 under the Mental Deficiency Act.
Primary amentia	90·77	60·6
Mongolism	0·97	5·5
Cretinism	0·39	2·05
Microcephaly	0·52	2·3
Hydrocephaly	0·33	1·09
Epilepsy	2·12	14·1
Cerebral paralysis	0·27	5·7
Paralysis and epilepsy	—	4·0
Various secondary amentia ..	4·63	3·9

The mass of feeble-minded are simply classed as amentia. This is chiefly due to physiological variation in the most variable structure of the body. The nervous system embryologically is of epithelial origin, and variations might also be expected in other epithelial structures. These variations, or stigmata, as single appearances are probably more common in otherwise normal children. When they are multiple, three or more, they suggest a general underlying cause of ectodermal defect, which may also be associated with nervous structures, and in this proportion occur at least twice as often among the mentally defective. Such stigmata as marked asymmetry of the skull, small-headedness, squints, congenital cataracts, defective auricles, vaulted narrow palate, slanting palpetral fissures, and webbed digits, are all more common in mentally defective in com-

binations, and the more numerous the combination the greater the probability of mental defect. One rare condition, the adenoma sebaceum may be said to be pathognomic of defect.

Want of physical symmetry is perhaps the most frequent and evident general character. There is also undue distribution of hair, the hairy face of many of these children being a noticeable feature. The external structures of the eyes often present stigmata ; squint being common ; coloboma of the iris or a tendency to a cleft in the eyelids are occasionally seen. Others are small dermoid growths about the lids, or even on the globe ; epicanthus, or the slanting almond eye of the Mongol. The ears, more than the eyes, are unsymmetrical, and often have clefts, or accessory nodules. A tiny depression from developmental defect, helical fistula, looking like a pin-hole, is frequently seen on the upper front part of the edge. Recent radiographic examinations have shewn numerous stigmata about the cranial bones in the mentally defective (*J.A.M.A.*, 1924. ii).

The shape of the head may be remarkable. There is a large macrocephalic type, square-headed, generally associated with a dull brain, in which the supporting structures are hypertrophied.

The simple hydrocephalic has a balloon-like head, the parietal and frontal bones being vaulted. The eyes seem in hydrocephalic infants as if laid on the floor of the orbits, as indeed they are. The child need not be defective ; thus a boy of 9 years old, with a head circumference of 25½ inches, was highly intelligent. A girl of 7 was the best in her class, although from the age of 3 months she had been a high-grade hydrocephalic. Many of these children are pert, and smart in their remarks, but almost imbecile in general conduct.

The rachitic form of hydrocephalic head has a broad, high forehead, the " Front Olympien " of French writers, but none of the ballooning in the other bones.

Hydrocephaly is sometimes stated to conduce to good mentality, but in this case it probably is rather the head of the *type cérébral* of French anthropologists. Frequently quoted examples are Sir Isaac Newton and Helmholtz. The last, as the writer remembers him, had the typical square-headed form, which might have been called rachitic, but did not appear as a former hydrocephalic.

Oxycephaly.—Oxycephaly is a condition which is, perhaps, commoner than one would judge from literature. It appears to be a congenital condition chiefly in boys, due to premature ossification of sutures about the cranial base. It causes visual troubles from about the second to the sixth year. The skull has unusual height. The name *Turmschadel*, tower skull, or turret head, well describes it. Pressure from within causes the orbits to be shallow, the eyes protrude, and there is divergent squint. Vision becomes impaired, and blindness slowly ensues. There is optic neuritis, with choked disc and sometimes hæmorrhages, and subsequently the slow onset

of atrophy. Headache is often a complaint, and although mentality may be dull, it is doubtful whether mental defect is a necessary consequence. Some cases have shewn webbing of fingers and toes, and inability to fully extend the elbow-joints. Early decompression operation is indicated.

Davis, in an exhaustive paper, demonstrates many degrees of the condition (*Am. J. Ophth.*, 1925. 513). Butterworth (*Arch. of Ped.*, 1916. 388) records two brothers with a history of the same condition in a grandfather. Dr. Josephine Young, in Chicago, records a mother and two children affected (*J. Neur. & Ment. Dis.*, 1916. i. 176). Meltzer (*Neurol. Centralblatt.*, 1908. No. 12) attributes the condition from an examination of twenty cases to hydrocephalus and rickets.

Microcephaly.—Although in any single individual the mental capacity is not necessarily indicated by head circumference, when numbers are measured the larger the average circumference of the head the greater the mental ability (21,930 cases). The broad-headed are superior to the long-headed, and brachycephaly increases through the ages with increase of civilization. The circumference of the head is less in children with abnormalities (2244) than in children in general (16,473) according to Arthur MacDonald.

Bayerthal (*Zeit. f. S.*, 1911. 742) thinks good intellectual conditions are excluded in seven-year-old boys, if the circumference is under 48 cm., and in girls under 47 cm. Boys are of greater head size than girls of the same age. At age 10 the limit is 49·5 cm. for boys and 48·5 for girls ; at 12 to 14 it is below 50·5 for boys and 48·5 for girls. With head circumference up to 2 cm. above these limits, good mental efficiency is exceptional. These are for German children. Dutch are very similar. Hamelberg, in Amsterdam (1913), measured 1600 ten-year-old boys. He concluded that boys with clear heads measured over 49·2 cm. and girls 48·4 cm.

The microcephalic child is a distinct type, usually of low grade mentally, and at once noticeable. The forehead is small, generally rather hairy and much sloped backwards, the vertex of the head seems pointed up and backwards ; lower jaw and face bones are poorly developed, except the nose, which, in comparison, seems over-developed and pronounced, giving a somewhat birdlike appearance. Two typical microcephalic imbecile dwarfs were a fashionable exhibit in Society under the name of the Aztecs after the Great Exhibition of 1851.

An account has been published (*J. of Nervous and Mental Disease*, 1916. 177) of Shah Dahla's Mice ; a set of feeble-minded microcephalic imbeciles, who are said to breed true and to be kept up by the priests of an Indian shrine, for whom they beg.

Cretinism.—Before many examinations have been made two types will impress themselves on the mind : the cretin and the mongol.

The cause of cretinism is unknown. Since the days of Paracelsus, who, in his work *De generatione Stultorum*, associated this with goitre, it has been recognized as due to thyroidal trouble, or now, at least, hypothyroidism. The cretinous condition may vary in its mental effects from slight defect to idiocy. Bad cases cannot speak, and fortunately are incapable of reproduction. The next stage speak but little. Their appearance of thick coarse hair and skin, spade-like hands, large head, fat pads and prominent abdomen, with general infantile build is characteristic. Their movements are slow, and the whole picture is sluggish and torpid. A few cases do astonishingly well if thyroid treatment is begun early. One child the writer dealt with: When first seen as a hospital in-patient at the age of 7, she looked about 5 or 6 months old, and did not sit up properly. With assiduous thyroid treatment in the next four years, she grew to normal appearance and passed through the special class with ease. Not many cases gain like this, but the treatment should never be omitted.

David Starr Jordan gives a picture of the Valley of Aosta when he visited it in 1897 and saw hundreds of cretins. The severe military selection of this region had removed the healthy males, and left the goitrous and cretinous to carry on. In 1910, when he visited it again, owing to the segregation of cretins into an asylum, and prevention of their marriage, cretins had disappeared (*Training School Bull.*, October 1915).

A want of iodine contributes to the goitrous condition, and the regular administration of small quantities of iodides is a public health measure in districts where iodine appears to have been washed out of the soil.

In earlier years of school-work in Bradford the author saw more cases of cretinism than of mongolism. Having noted many curved little fingers as prominent stigmata, it is possible now to suggest that the latter condition was often confused with the cretinous.

There may be slight or larval conditions of both forms of defect.

Mongolism.—The mongol is a well recognized type and more frequently diagnosed than formerly. Binet has described these children. With a little round head, chubby cheeks, rosy as if painted with rouge, oblique eyes, a nose broad at the basé and with a tip like a little ball, skin slightly yellow, limbs like india-rubber, so great is the looseness of the joints.

During his first year the mongol is rather drowsy and quiet, too "old-fashioned," as the mothers say. In the second or third year he becomes lively. His countenance acquires a comic, jolly expression, his imitative instincts become curiously developed, and as a general rule he is sweet tempered and even affectionate. They resemble one another, and all promise much and achieve little;

they are imitative and learn a little in this way, but they never cease to be imbeciles. This picturesque description is exact and true. The facies has broad zygomatic arches with the oblique small palpebral fissure that gives the mongolic expression, and the occiput has a shorn-off appearance. There is frequently epicanthus, and the majority have blepharitis, sometimes ectropion. Squint is common, and lens changes are found in the form of dots and often stellate polar striæ. Nystagmus is more common than in any other general group of children seen in school. The tongue also has characteristic appearances ; in the infant it is often protruded. After 3 years of age it shews transverse fissures, sometimes is called the scrotal tongue, and usually there are hypertrophic pyriform papillæ ; the lower lip is often protruded. None of these signs are pathognomonic. Any one may be found in a quite normal individual. It is the concurrence of a large number that gives the indication.

The cretin is torpid, the mongol may be apathetic or lively, sometimes fond of jokes and activity, and given to explosive laughter. Most mongols die in later childhood from diarrhœa, broncho-pneumonia, or some acute disease. The cretin, apart from the peculiar type, is otherwise a healthily formed little person, but the mongol is unfinished and incomplete. There is no evidence of hereditary disease like syphilis or tubercle. It was formerly supposed that they were the last child of a big family, but this only holds for half the number, although the average age of the mother lies between 35 and 40 years. With all births, 2·1 per cent. occur when the mother is 40 or older ; with mentally defective (excluding mongols) 4·9 per cent. have mothers of 40 or more ; but in the case of mongols 36·9 have old mothers (Marston, *Psych. Clinic*, 1925. 139). Usually they come from good families, and two mongols in one family is rare. Neurologically the family history is clear. There are at least a couple of dozen cases published where one of twins was a mongol, but these are all cases of non-identical twins. Two cases where uniovular twins were both mongols are published. Evidently the cause, whatever it is, reaches back to the single ovum. The mongol is still a mystery in causation.

Physically, they present many stigmata of eye and ear. The thyroid is not enlarged. The heart is seldom normal, various malformations, such as patent foramen ovale, may occur ; there is a tendency to hernia, especially umbilical ; although bull-necked and with wrinkled forehead, the joints are all loose, and as Crookshank notices, the mongol takes after the ourang and sits cross-legged like a Buddha. Crookshank suggests that mongolism does not occur among negroes or Jews, and it is probably less common, although it does exist, in Semites. The mental type is low, about B.S. IV. They get on with those of their own mental age, older children worry them. They are often echolalic, and have defective

speech, forming consonants badly; reading and writing are beyond their powers, but most of them like music.

During childhood growth is slow, the fontanelles close late, the teeth do not appear till perhaps the third or fourth year, but if the child survives till puberty, considerable growth may take place.

The writer found a tall, clean-limbed boy of good family, pleasing appearance, and winning ways, whose speech was poor and occupation chiefly with the violin; he was about 12 years old, and did not look in any way defective, but could not be taught to read or write, and ultimately, after consultation with various authorities, was decided to be a mongol who would not further improve.

The diagnosis of typical mongolism ought to be clear, and when made is hopeless for educational improvement, although the child may seem promising. They are always clean, neat, and tidy.

These cases have been set forth, as seen in the majority, in distinct examples, but they may shade off into each other, and into imbecility or normality. There are cases, like the boy with the fiddle, in which judgment is difficult, or suspicion not aroused till well on in school days. Fortunately, they can be held in suspense in most instances, the primary judgment of mental defect having been made, the secondary and final diagnosis can be left over. Then it may be found that a supposed mongol reacts speedily to thyroid treatment, or a cretin shews no effects. In either case it will be long before the first verdict has to be altered.

The Diagnosis of Epilepsy.—Epilepsy has been grouped for educational purposes with the Mentally Defective since the Elementary Education (Defective and Epileptic) Act, 1899, and rightly so, for continued recurrence of epileptic seizures inevitably results in mental degradation.

Education Authorities now have the duty under Section 55 of the Education Act, 1921, of ascertaining what children in their areas are epileptic children, that is to say, what children not being idiots or imbeciles are unfit by reason of severe epilepsy to attend the ordinary public elementary schools.

The educational problem is part of the general social problem of dealing with the epileptic. The exact nature of mechanism causing the symptom of epilepsy is not known, except that epilepsy is generally associated with damage to cerebral structure. About one-tenth of the cases in institutions have had cerebral trauma at birth.

Heredity plays its part in transmitting a nervous make up that tends to massive neuronic discharges such as characterize epilepsy. There are said to be epileptic families, and any of the many contributory circumstances may easily upset the balance, so that one of these individuals becomes epileptic.

Some years ago Shuttleworth referred to a family of ten children with epileptic parents, of whom eight became epileptic. Probably

up to a third of the epileptic children seen will have some epilepsy noted in the family history. Gowers traced heredity in 43 per cent. of all his cases, whilst Osler thought it not of importance. Just as in the mentally defective, stigmata pointed to degenerate variations, here also the presence of numerous stigmata point to a probable instability that argues badly for the progress of the case.

Epilepsy in young subjects, generally, is accompanied by numerous stigmata. Stoddart says an epileptic before the age of seven will become imbecile. Absence of stigmata does not exclude serious epilepsy of chronic nature. It is the highest neurons that are affected. In an ordinary case at irregular intervals a fit occurs, and the neurons seem to discharge *en masse*, loss of consciousness being typical of the epileptic crisis.

People associated with epileptics—from a change in irritability or temper—may be able to suspect a coming attack. Many sufferers, for a minute or two before a crisis, have subjective sensations, the epileptic aura, either vague abdominal feelings or a sense of strangeness, or want of orientation, or some particular sensation or feeling of skin or special senses, like taste or smell or some hallucination of sight. The aura is not very commonly noticed by children. The usual form is major epilepsy, with a sudden loss of consciousness. There is pallor of the face, a shriek or yell, the epileptic cry, and a tonic contraction of the muscles. The patient, without regard to time or place, instantaneously falls, and may seriously hurt himself, by wounding or bruising, by burning in a fire, or even drowning. During the spasm the face becomes dusky with congestion; in a minute or so, the muscles begin to tremble, and then contract in violent clonic convulsions, which last for a minute or two, then gradually cease. The tongue can be bitten, so that blood-stained saliva dribbles, and the sphincters are relaxed. If left the patient will sleep for an hour or two, awaking in a dreamy, muddled state, with some feeling of *malaise* or headache. Some attacks are serious, some mild. The above is an average description.

The epilepsia minor or *petit mal* is less obtrusive, but intellectually and temperamentally seems more damaging. A little pallor of the face, a momentary loss of consciousness, without necessarily falling down, some very slight movements, a turn of the head, twist of the mouth, or rolling up of the eyes, and the attack is over; although rarely it may be succeeded by a queer automatic condition, in which the functions of highest controlling neurons are for a time in abeyance. Any sudden temporary pallor, sudden loss of consciousness, or falling down suggests epilepsy. Faints, which may at first seem to be *petit mal*, occur in children who are ill-nourished and out of tone. Prolonged standing in one position may thus cause syncope. Another variety, where the child goes pale, but never becomes really unconscious, may last up to ten minutes, and usually occurs

with some such excitement as preparing to go off to school. It is probably due to splanchnic want of tone. They are not epileptic, and Hutchison (*Brit. Journ. Child. Dis.*, 1916. ii. 11) describes them as being relieved by tonics such as strychnine.

Sometimes the epilepsy is masked, so that fits are not noticed. A common condition is for fits to occur only in the early morning, and be so slight that beyond bed-wetting, biting of the tongue, or perhaps staining the pillow, nothing would be known of them. Other rarer forms occur, but all are based on these two as the plan. A child with occasional vague headaches and at times a queer, dreamy manner has to be thought of as possible epileptic.

The habit of the nervous system to produce these attacks may easily develop. The attack itself damages the brain structures; indeed, in chronic epileptics, damage may be seen in little dilated stellate venules on the skin, or tiny petechial hæmorrhages.

The convulsions of infancy cannot be distinguished from epileptic convulsions, but they are not the inevitable forerunners of the disease. Koplik gives the advice that unless there is a family history of epilepsy, it is not safe to diagnose it in infancy. Others attempt a diagnosis, in that infantile convulsions accompanied by a rise of temperature are held as unlikely to be followed by epilepsy. Continued and repeated convulsions, however, are damaging to the later mental and moral, more even than the intellectual, condition of the infant.

The avoidance of infant convulsions is a definite factor in the prophylaxis of epilepsy. Where the attacks resemble *petit mal* in infancy, the outlook is graver than with convulsions; such children are disposed to die suddenly.

Alcoholism is not uncommon in the family history, but whether it is a cause is doubtful. Congenital syphilis one would almost expect as a precursor, and Dr. Kate Fraser found half her epileptic cases, in the Govan schools, positive reactors to Wasserman's test. A number at Earlswood gave 59 per cent. positive. Generally, as a class, epileptics appear to give the highest proportion.

In the epileptic history, most attacks begin in the first year of life. Each year the number of first attacks diminish till just before puberty, when there is again an increase spread over the years 11–14. Frequent attacks, beginning in infancy, damage the supra-granular cortex to such an extent that the children become institutional cases. The outlook for all beginning before 10 years old is serious. About 70 to 80 per cent. of cases begin before school days are over.

The diagnosis may be difficult. Hoche, years ago, shewed that as between epilepsy and hysteria no one sign was pathognomic. During the War one learned that, whilst the majority of cases were sharply differentiated from hysteria, there were cases giving a past history of one or two epileptic attacks in childhood and apparently

complete recovery, where years after an epilepsy had recurred which could not be taken to be functional. On the other hand, some cases which seemed purely epileptic appeared to recover completely. In Roman times epileptics were forbidden in public assemblies. The morbus comitialis occasionally occurring from imitation.

The outlook for recovery in children where fits have existed for a year or two is poor.

Where teachers are concerned the interim diagnosis of hysteria is the safest, until the condition is indubitable, as epilepsy means loss of occupation. The hysterical case, again, does not deteriorate in the same degree as the chronic epileptic. Chorea occasionally may be thought of, and tics in connection with *petit mal*, but a careful examination of all the bearings will determine the case.

Educational Treatment of Epilepsy.—Educationally, these children usually are treated in regard to other scholars. An epileptic fit in school may be a great shock. If frequently repeated it upsets the school-work. In some cases where fits are rare, or only nocturnal, or out of school, there is scarcely reason to exclude the child. Brilliant scholars are occasionally recorded to have been epileptics. Both Julius Cæsar and Napoleon are credited with the disorder. Epileptics have distinguished themselves at school and university and in after life. The writer can recall several cases, none with frequent, but yet with recurrent and typical attacks, who have carried on over several decades. On the other hand, a young woman diagnosed as epileptic from appearance and speech had not had any fits for many years. The slow, measured speech developed in a chronic epileptic is characteristic. Several authors note the want of tone in what is called " Plateau Speech," and Scripture, who has carefully analysed it, states that the monotone of a sentence, dropping by a third at the end, distinguishes the case from a normal or an hysterical person. This slowing of the nervous reaction shews up in mental testing. There is usually considerable scattering on the intelligence tests, and the motor tests are all slowed down, and worse on repetition. Wallin points this out as characteristic (*Psych. Clin.*, 1917. 179).

In school, dullness of the children, especially after any attack, their irregular tempers, irascibility, and sometimes senseless rages are noticeable. A slow deterioration goes on proportionate to the violence and frequence of the fits. In *petit mal*, however, mental results are occasionally out of proportion to the obvious attacks of disease. Lessons recently learned may be lost after a fit, and after a slight and almost unnoticed occurrence children may behave in the most bizarre way. A child may be seen to rise up in its place, go to a corner, or walk round the class, and then go back and sit down. A girl of 10 interrupted in course of such a walk was unintelligent, and mumbled something without any bearing at the time.

Another, a small boy supposed to have a tic, from the twist of the mouth at frequent intervals, was only detected as *petit mal* from the progressive mental deterioration.

The Public Health Aspect.—Over twenty years ago the Public Health aspect of the epileptic child was summed in the following sentences—

> An epileptic is always a source of trouble, not only to himself, but to others. The attacks are often exceedingly alarming, and when, as is frequently the case, a whole household, perhaps of tired workers, are roused night after night by shrieks of a relative, or when they are subject to recurrent though transient attacks of aberration, violence, or even more persistent unreasonableness and wilfulness by epileptic children, life becomes a burden. The great unseen burden exists, and the ever present fear of accident, or possibly of the criminal or murderous outbreaks that one hears of, presses hourly on hundreds.
>
> Education for epileptics, in practically all cases, can only be properly managed in residential institutions. The ordinary schools are thereby freed from interruption, the patients safeguarded from accident, and the lives of their immediate relatives freed from an intolerable strain and anxiety. Epileptic children will always have to be separately cared for, housed and educated apart from older patients; they are best treated in a school colony, which should be large enough to admit of classification, and to which every case, however complicated, could be sent.
>
> No arrangements will be satisfactory unless all epileptic cases can be taken, however degraded, troublesome, or afflicted they may be (*L.C.C. M.O. Ed.*, 1906. 41).

The treatment of epileptic children in a residential school by others, and provision educationally for them, both in the way of hand and muscular work, and of suitable dieting, is superior to any treatment at home or in a day school. Yet a few hours in such a school is an eerie business, as one after another cries out, or drops down, and is assisted by his mates.

Shuttleworth catalogued several hundreds of epileptic children examined for the London School Board, and decided that 17 per cent. could continue in the ordinary school, 27·5 per cent. in special schools, and 40 per cent. should be sent to residential epileptic institutions, the remaining 15·5 per cent. being suitable for asylums. They are a group who would all be certified under the Mental Deficiency Act, 1913.

Education will be wasted if young children becoming chronic epileptics are treated as normal; they will deteriorate and be unable to make use of what is taught.

Administrative Problems of Epilepsy.—Prophylaxis in beginning cases of epilepsy is generally neglected. Education authorities have farmed out the worst cases. Every case should be sent to a residential school of recovery for a time. The limited accommodation that exists mostly came through voluntary agencies, who now rather stand in the way of better provision.

The first residential regulations of the Board of Education in restricting separate houses to 15 inmates thereby made overhead charges excessive. Separate houses, limited to 25 inmates, although not a necessity medically, are desirable.

Children with health and physique under medical control, and academic work put in a subsidiary position, will do better in such establishments than under other conditions. Every accident, scratch, or burn should be recorded. Bruises, rubbed friction wounds of skin in accessible places, biting and sucking of the upper arms may all occur and unless recorded with date and appearance may easily be the cause of trouble.

Some will progress to dementia, others will have the disease effects slowed down or arrested. Dr. McDougall, the Medical Superintendent of the David Lewis Colony, reported that many were there prevented becoming chronic epileptics.

Those who improved sufficiently might return to ordinary school; whilst the others would remain. Later the employment and safety of an epileptic colony offers most of them the best chance of comfort and usefulness in life.

Parents often refuse to believe the seriousness of outlook. Section 53 of the Education Act lays the duty on the parent of an epileptic child over 7 years of age, to cause it to attend any special school within reach of its home.

By Section 54, if the L.E.A. is not satisfied with the provision they may require a parent to send the child to a school, or may get an order from a Court of summary jurisdiction compelling its attendance. If school is residential the parent has to consent in writing, but consent must not be unreasonably withheld. Consent is not to be deemed unreasonably withheld if with the *bona-fide* intention of benefiting the child. This is a weak provision, as a parent might urge that the child had to see a particular doctor once a week, and be quite *bona fide* in the matter, the ultimate result being to saddle the community with a chronic epileptic dement.

It is difficult to estimate numbers of children who could be under care, but are being neglected so far as the prophylaxis of chronic epilepsy is concerned. The school medical officer is a protector of the community against development of this disorder, and should work to save them from future risks.

Epilepsy is perhaps even now decreasing in prevalence. Classification and care in large residential schools is the solution. Epileptics are an uninteresting lot, and the doctor may be disposed to let people have their own way. *Laissez-faire* here is the easiest for him. There are many obstacles. The L.E.A. has to charge parents its costs, instead of regarding this as an insurance. The written consent of parents has to be obtained. The institutions reserve the right to choose their own cases for admission.

For London there are probably a thousand school children who require prophylaxis against chronic epilepsy, by education and hygienic living, but the difficulties in the way are great. About a hundred are in certified or other residential colony schools. Others are those not at school, demented, imbecile, and idiotic in institutions and asylums, where epilepsy is not the main trouble.

The L.C.C. provision from a medical point of view (1924) is—

"*Epileptics.*—The Council has made arrangements for sending children suffering from chronic epilepsy to such an extent as to unfit them for an ordinary school, but yet whose mental state is such as to permit of their deriving benefit from education, to epileptic colony schools if they are between the ages of 7 and 13, and subject to the parents' consent. The authorities of the epileptic colonies have the right of selection. If admitted, children may be retained until the age of 16." If not admitted, apparently, the Council makes no provision, and there are some hundreds at no school or institution. The condition and provision for children who are epileptics all over the country is evidently still in need of considerable improvement, and the question should be faced, and not camouflaged in reports.

Dangerous Occupations.—Later-life occupations have to be considered for the pupils. Many an epileptic can be well trained in a colony and turn his life to profitable account there in such work as gardening, fruit-growing, or farming. Certain occupations are quite unsuitable. He should never be occupied on ladders, scaffolds, or heights where he might fall. He should not work among moving machinery, nor in any place where he might be exposed to flames or fire. Falling into water is another danger, and there are remote risks of live wires, or rails, or traffic of any kind. He must not take any responsibility, as on shipboard, railways, or in military duty. The danger to others from epileptics in the machinery of a civilized community is so great that every inducement should be held out to make them become self-supporting workers in special industrial colonies.

Epiloia or Tuberose Sclerosis.—Epilepsy is associated in one very rare syndrome, which needs to be known for school-work. Epilepsy, mental defect, and adenoma sebaceum on the face is described as epiloia, or on the pathological findings tuberose sclerosis. Most cases degenerate early, and die as idiots. Small tumour masses of apparently congenital formation are found in the kidney, heart, and brain. The brain convolutions at places are thickened and raised.

The important point in school-work is the outlook for a child with mental defect and adenoma sebaceum, and that the gravity is increased by the occurrence of epileptic attacks. The adenoma forms small waxy, rounded papules scattered about the cheeks or

chin. Sometimes several cases of adenoma sebaceum occur in a family. Hamilton, of Sydney, recently reported a case in which the girl, her mother, and her aunt and grandmother on the mother's side were all affected and mentally defective.

Many years ago, one of the medical women diagnosed an eruption on an unwholesome-looking girl of about 11 years of age, as adenoma sebaceum. I visited the school and agreed with the diagnosis ; although the child was mentally dull she seemed otherwise normal.

Environmental Causes of Mental Defect.—Environmental cases from an early age occur in contradistinction to those congenital ones. Lead poisoning : The water of certain moorland districts is liable at times to take up lead from supply pipes. Although the effects cannot be looked on as likely to be met in school, the writer can recall a case of a girl of 18 blind from lead encephalopathy.

In Australia, however, lead poisoning is an ever-present danger to young children. Dr. Lockhart Gibson (*Med. Journ. of Aust.*, 1917. ii. 48) in several papers pointed out how a paralytic squint, without rise of temperature, in a child below 8 years of age must be considered as a possibility of plumbism. Many Australian cases seen with optic neuritis are at first diagnosed as meningitis or cerebral tumour.

The Medical Congress at Brisbane in 1920 passed a resolution calling for statutory prohibition of "paint containing lead on veranda railings and other outdoor surfaces exposed to the hands of small children ; from which cause every year there are contributed cases of paralysis and blindness, while in older children are sown the seeds of ultimately fatal disease of the kidneys."

Gibson pointed out the mechanism of paint containing lead carbonate being safe for a year or so, and then, through hot sunshine, powdering, and being taken up under the nails of the children.

A similar mechanism is regarded as to the cause of numerous cases due to yellow lead chromate (*L'Igiéne della Scuóla*, 1917. 276).

The relation between good physique and good mentality is indubitable. The relation, however, between the debility of undernourished children, and their mental lack of drive is more difficult to demonstrate, but is most evident to the medical investigator in the schools, not merely engaged in routine work. The cup of milk or the regular meal, the open air and the sunshine, all have noticeable if not measurable effects. These effects become still more obvious in certain cases.

Hookworm disease, which is prevalent in the coastal regions of Queensland, and in many other hot and moist climates, arrests both bodily and mental development in children. They are dwarfed in growth, and the prolonged anæmia is shewn by the hæmoglobin content of 60 per cent. of the children being below 70 on Tallquist's

scale. This, and the toxæmia, cause arrest in mentality, judged by poor performance of B.S. and Porteus tests. The retardation amounting to nine months in groups of slight cases and two years in the group of heavily infected cases (Waite, *Med. Journ. of Aust.*, 1919. i. 14). Their condition appears to have some light thrown on it by the observations of Dr. Leipoldt in the Transvaal. Chronic fatigue resulting from malaria made many children living in low-lying districts unfit for work after an hour in school. Such children would be classified as mentally defective through "superficial examination with mental tests," shewing retardation from one to two and a half years. Removed from the malarious environment, and given proper tonic treatment, the children rapidly improve (*Transvaal M.O. Report*, 1920).

Hysteria.—Hysteria and functional disorders are common as superadded elements in children's troubles, but the diagnosis of hysteria must be made definitely. Action must not be taken on an assumption.

The importance of imitation as part of natural education and the accessibility to the child's mind of suggestions explain these symptoms. The very accents of the mother tongue are the result of such psychic factors. The doctrines of superstition are only implanted at early ages.

In days when ignorance of natural causes was profound, and the mysteries of religion and the spirit were all powerful, these psychical infections flared up here and there. The stories of the Lancashire witches in our own country are almost unbelievable, but true; so, too, the children's crusade (1237) and the great chorea (1458). Outbreaks still occur here and there abroad, but are rare in Anglo-Saxon countries. Haygarth, of Chester, narrates an epidemic of convulsions in Anglesey (1796). He had known of a similar epidemic elsewhere thirty years previously.

A curious emotional, affected type seen frequently in the examination of theatrical children, is subject to isolated functional symptoms. Most cases seen in London are children of alien extraction.

Functional symptoms as met in neurotic school children are exemplified by the following, whom, except the last two, the writer recalls from having treated them.

A child of four speaks little in a slow, staccato way, has very feeble knee-jerks, and has never been able to stand without holding on, or to walk by herself. Put on small doses of strychnine for diagnostic reasons, she soon became practically normal.

An Irish boy, caned at school, developed typical contracture of the whole arm within a few hours. He was cured at once by forcible extension continued over a few minutes.

A ten-year-old girl attempting to put a nail in her shoe, the head of the nail breaks, and the piece strikes her eye. Next day

she is completely blind in that eye. The pupil reacts normally, and examination with red and green glasses shews that there is binocular vision. Suggestion in the dark room restores normal acuity in a few minutes.

A small Jewish boy who has been thoroughly frightened develops violent tremors, making his writing illegible. It is almost normal whilst the observer's hand is pressed on the top of his head, and he is told that he will get well.

A girl of 10, supposed to have congenital dislocation of both hips, cannot stand, collapses on the attempt. There is no deformity, and lying on her back she has complete power in her legs. The condition is astasia abasia. It permanently vanished on pressing the thumb on the root of her nose, and assuring her that she could now stand up all right, which she did. It recurred some years later and was similarly relieved.

A London child who had had slight right-sided paresis after an abortive attack of encephalitis, which scarcely interfered with his work, developed hemiplegia. When interested he sometimes used the affected arm. Dr. Shrubsall was satisfied that it was a functional addition, and sent him to the country, when it rapidly got better, to recur temporarily under strain (*Journ. Neurol. and Psychopath.*, 1923. 238).

A girl at the age of 9 became paralysed in one arm before an examination. Next year it was the opposite arm. This recurred with each examination (*Z.*, 1892. 274).

There are many varieties, usually as single simple paralyses or contractures. There are isolated cases of long-enduring speech or auditory defects too, probably of this nature.

In the East End of London, during the War, many children shewed a fine tremor in their writing, if it was examined with care. Possibly this was due to the strain of air raids. Tremor in writing is not an uncommon functional sign.

Some of these cases seem fat and healthy, but are of neurotic make-up. The majority are debilitated, underfed, and relatively overwrought.

Where children are under considerable educational strain, and but poorly nourished, spending hours together and attuned to the same outlook, outbreaks of a functional nature in small groups may occur. The outbreak may take various forms, but all of a group are similarly affected.

The faintings in young ladies' academies in the past were the nearest approach to school epidemics we have had.

Many years ago, a Standard II child in a Hackney school, with an infantile palsy affecting her left arm, broke the right. She was out of school for some time, but within a few days of her return three girls lost the use of their left arms, and a fourth, who was supposed

to be rheumatic, had such violent pains in her arm that she could do nothing except hold it against her side. The head mistress wrote to ask what was to be done. The diagnosis was clear. Dr. A. H. Hogarth went down to confirm it, and examined the children. By suggestion he got them to move their arms freely and painlessly, and there it ended. One was very undeveloped, and one affected in speech and manner, another supposed to have heart disease, and two of them were Poles (*L.C.C. Med. Off. Ed.*, 1907. 32).

This represented the beginnings of a form of psychical contagion not uncommon on the Continent, chiefly in German-speaking schools.

In a Catholic school at Biberach in 1892, before the days of sleepy sickness, a curious outbreak originated. A girl of 13 repeatedly fell into a sleepy condition in church, then it occurred in school, then in a few days a dozen girls in her class were affected. They were all undeveloped, pale, debilitated children and fell into a stupor in the second hour in school. They were not awakened by tickling or pricking, carried out movements when ordered, and could be awakened by blowing on them. This was an example of autohypnosis.

Next year, after the Biberach outbreak, in a village near, at Lignitz, a girl fainted, and within a few days others began with tremors in right hand; many were affected, some to general convulsions, 38 girls and 32 boys shewing signs.

There is recorded school closure at Budapest for hysterical coughs; another of expiratory spasms with strange animal noises after a girl had coughed, "like a horse sneezing."

Rembold, in Stuttgart, narrates an outbreak where, after an hour in church a girl fainted, and on return to school, in a short time, 25 others had developed the *Zitterkrankheit* (tremor hystericus), and about half of them passed into a sleep-like condition.

A Viennese school had to be closed (1897) for hiccups, affecting 28 of 35 girls, and a neighbouring one had 20 out of 50 affected. St. Vitus's dance, 26 out of 74 pupils, is recorded in a small school at Wildbad.

At Valle, in Austria, many girls, aged 10–12, had convulsive movements, loud sighs and red faces. They became giddy and several were unconscious.

The Klaraschule, in Basle, had an outbreak in the secondary girl's school, by a girl who had been frightened in the street and ran home and began to tremble, next day commencing the trembling in school. It extended over months and affected 62 children. Ten years later it happened again, and was energetically handled by the formation of a special class, which the youngsters called "Zitterklub Concordia"; 14 of them were debilitated and anæmic, and 17 purely imitative.

In Christiania, among boys aged 13 to 15, a boy, feeling faint in the gymnasium, the teacher took him on one side to loosen his clothes. In the meantime 9 other boys fell down, having fainted. One thinks of bad ventilation here.

The best known outbreak is that of 1905 at Meissen, when a girl of 13 began with trembling of the hands; the trouble extended till 250 girls in 35 classes suffered the attacks, which continued to come and go for hours daily, and several teachers were also affected.

In this case a child who had read in the papers that the Meissen children could not hold their pens, began to tremble at Chemnitz. The teacher having said in class that she hoped they would be spared the trouble at Meissen, in

a short time had 21 out of 35, both boys and girls, affected. It was a tremor which started when writing began, and got worse till the ataxic writing was illegible. The movements did not affect any other work.

A year later, a recurrence of about 35 cases at Meissen was stopped by a "Zitterklasse" kept going for a month.

There is naturally abundance of literature on the subject. An outbreak at Basle is described by Zollinger (*Ann. Suiss. d'Hyg. Scol.*, 1906. 20).

These histories point to the "Zitterklasse," and possibly therapeutic talks, as being superior to school closure.

The Meissen outbreak is semi-officially described in the *Zeit. f. Kinderforsch.*, 1906. vii, and a critical summary of the literature was published by Dr. W. H. Burnham as "Suggestion in Elementary Education," in 1912, in the *Proceedings of the American School Hygiene Association.*

These are recorded, with other instances, scattered through the pages of the *Zeit. f. Schulgesundheitspflege.* There is recorded a psychical epidemic of pre-war suicide. In the Report for 1913, on the training college for 156 teachers at Komotau in Bohemia, is a statement of suicides. "Three cases could be determined; indeed there were grounds for believing that the suicides had a shattering effect on the mental balance of the pupils, and the school year ended with a fourth suicide."

Child Suicide.—The writer has not come across a scholar's suicide in this country, but with a universal system of education extending to sixteen years, and especially if the academic examination system should be allowed its present weight, some cases may be expected in a few years. In 1923 the Registrar-General for England and Wales reports three suicides under 15 years of age: a boy who took prussic acid and two girls who were drowned.

Abroad, child suicide occurs from time to time. In Italy the rate is stationary, and it is confined to urban life. School plays little part, home conditions affect it, but it is most often related to mystical and religious causes, about puberty (*Archiv. di Anthrop. Crim.*, xxxiv. 1913). Of 236 cases under 15 collected by Dr. Sacerdote, 67·5 per cent. were boys.

In Switzerland it prevails less in the Catholic cantons, but these are the non-industrial areas. Professor Lazar and Redlich in Vienna dealt with 9 cases and 61 attempts, all about 15 to 16 years old. They concluded that school had little influence. The school and family were social factors, but heredity and a psychopathic tendency were chief. These children, having little regard for the truth, were almost all liars, generally of good intelligence and very precocious (*Zeit. f. S.*, 1914. 777).

Baer noted that as the annual variations in figures for scholars and adults differed so greatly, different causes must be acting.

Heller summed up, "the sons of some of the best families, from

false pride, and through unfortunate school reports, give up their lives" (*Zeit. f. S.*, 1911. 59). For Prussia in the 1911 returns, suicides under 15 were 87, between 15 and 20, some 683, the next, 20–25, period, 890.

Dornblüth assigned one quarter of the child suicides to examination anxiety; and there is also an enormous amount of non-fatal damage (*Zeit. f. S.*, 1907. 491).

As a result of enquiries by a Committee, it was decided that suicide among high school students was due to too long lessons in school, too much homework, and too little sleep; and an official Memorandum of the Prussian Ministry (November 18, 1909) was issued reducing lessons to 45 minutes' duration, increasing free afternoons, and providing that there should be no increase of homework.

Professor Khlopin, of St. Petersburg, in 1907, thought the increasing numbers in Russia appalling. It had become almost a school disease. They had an official printed form for reporting school suicides to the Ministry, which is given in his paper at the London International Congress (i. 224).

There were three Russian boys to each girl suicide, and about one-third of the attempts unsuccessful; age 15 to 16 is the peak year. In attempts, school causes are stated as chief, in the others, "pride engendered at home" is assigned a place.

An onlooker can scarcely hope to assess accurately, but it is just possible that the real cause is the pressure of the educational system, which by examinations about the age of 15 or 16, stamps the child as inferior or otherwise. The pre-War German boy who failed in his examination, instead of having one year's service as a volunteer, had to do three as ordinary *Kanonenfutter*.

These considerations, acting on a child of psychopathic tendencies, especially if he feels that by failure he has disgraced his family, must have very powerful debasing moral effects, so that although the school itself may not be to blame, it is what stands behind the school examination that is the trouble.

Dementia Præcox.—In dealing with unstable mentality, reference was made to the overpowering effect which environment may have in developing ideas that trouble the whole course of life. Such disturbance comes mainly through interference with, or inhibition of, the control by the highest levels of the nervous system. The ordinary processes of organic life and automatic existence, however, can be carried on without such aid of the highest levels, and in the moral imbecile there is a lack of development here in an otherwise normal person.

Another set of cases emerge after puberty. In these some of the temporary peculiarities of the adolescent may appear grotesquely exaggerated. At first, it is not so much intellectual as emotional defect which is the common symptom. This is a prelude to different

trains of conduct which all point to mental degradation, and the majority end in imbecility.

This condition of adolescent insanity has been noticed for many years. It was described by Clouston as "postponed idiocy," and formulated as a definite disorder by Kraepelin, who called it dementia præcox.

Only its beginnings will be met, even in secondary schools, but it may be encountered later among teachers. It is usually a slow process and although beginning with adolescence, many cases are not diagnosed before the age of 20–25 years.

Mott has shewn that some toxic condition, due to a deficiency of oxidation processes, seems to affect neurons, developing at puberty. There is also a want of gradual development in the sex glands. The common story is of a clever and accomplished scholar—although they are by no means all clever or accomplished—losing capacity at school. The great spurt of adolescent evolution fails, but careful observers have noted earlier symptoms. These children, however clever, are disposed to be temperamentally peculiar. They are given to brooding, and not associating with their fellows. Often some gaucherie of adolescence is stereotyped by a queer attitude, a stiff shoulder, a neck carried with a twist, or a strange mannerism of speaking or writing. Later writing may be seen to be touched up, and to have bizarre phrases, or an irrelevant sentence repeatedly thrown in. They act in an indescribable, but somewhat foolish and childish way. They seem lifeless, wanting in spontaneity or activity, are affected, reserved and obstinate, only complying with rules and regulations under a kind of sullen compulsion.

They frequently avoid conflicts of reality by retreating into a life of phantasy ; instead of adequate response, they do nothing. They understand perfectly, have good memory, and realize what is said, but their reply is delayed and slow, and they do not reason clearly. Their attention is poor, and sense of duty weakened. They fail to keep appointments or are always late.

If not detected, they may in the course of a year or two, commit some dangerous crime, as fear of punishment will scarcely weigh with them. Intellectually, they may talk and argue, sometimes in an inflated and bombastic way, dragging in little jokes or pet phrases of their own.

Sometimes the onset seems sudden. A hitherto brilliant girl going in for her degree takes to aimless wandering in the park in the morning instead of going to her classes, and has nothing to say for herself, and no reason to give ; but ultimately requires care.

Most cases, where this disorder is suspected, steadily deteriorate. Some there are who through a mental breakdown have been removed from school, and after a quiet year or two in the post-adolescent period, manage to continue on a lower mental plane. The mentality

may not be obvious, as their memory has kept much of the former attainments. They are slow and accomplish nothing. Sometimes trying sundry tasks and, almost before beginning, giving each of them up; or they take to the simple life. Existence is continued in a cranky, curious, obstinate, careless, and untidy way.

Many cases are missed in what lunacy experts regard as the curable stage of the disease, if there is such a stage.

This disorder must be considered wherever bizarre conduct at adolescence crops up, with other symptoms. If suspected early, expert diagnosis should be obtained, as a mistake might easily be made, and every precaution and delay is justifiable ere the serious and hopeless diagnosis of dementia præcox is finally formulated.

Whether any case can be saved by mental hygiene is uncertain. Occupational activities are said to have useful therapeutic results. The idea of early hygiene appears to have developed with the psychogenic explanation put forward by Jung and others. Seeking a psychogenic origin seems like putting the cart before the horse. In any case where diagnosis is clear, prognosis for mental health is utterly bad. Probably the next considerable advance in neurology will be made through early observations of conduct in this dementia præcox of the cortex, and the pathologically somewhat similar, but not progressive or continuous effects of encephalitis lethargica.

The causation is still a mystery. It is not an hereditary affair. Canavan and Clarke followed out the families in 1000 former cases in Boston, and in 463 children, the result of 136 matings, the nervous and other conditions of the children were scarcely different from normal (*Mental Hygiene*, vii. 137).

Sequelæ of Encephalitis Lethargica.—The mental effects after an attack of encephalitis lethargica (p. 716) are more serious in children than in older persons. About 10 per cent. make a complete recovery, 20 per cent. are functionally sound, and the remainder present all kinds of symptoms, the chief disorder being profound emotional instability.

Sleeplessness at nights, sometimes with considerable excitement and activity, and sleepiness in the daytime, occurs in early months of convalescence in about a third of the children. More frequently there are conduct changes, and about a quarter recover with impaired intelligence. Twitchings, tremors, or fits occur in a tenth, and ocular signs and symptoms are nearly as common. It is sometimes difficult to distinguish symptoms from sequelæ. There may be remissions and relapses, and there is likely to be increase, especially in some of the moral defects, for months afterwards.

Cruchet described the bradykinetic syndrome, which is commonly spoken of as Parkinsonism. This is a slowness in action or thought, mere slowness without other defect, and it is common.

In school the teachers note that the work falls off, the attention

wanders, and there may be sleepiness. A stiff posture may remain, hypertonus without spasticity, the body turning as a whole, like a lay figure, and also choreiform movements, or rarely, tremors. Moral defects become obvious, and purposeless acts of theft, impulsive acts of destructiveness, rages or violent conduct are obtrusive. A child that was law abiding, of exemplary conduct, and earnest at work, in the next few months becomes noisy, impudent, and incorrigible. Although he may still manage intelligence tests well, in school he is practically ineducable from want of attention or respect.

A good survey of these cases is by Professor A. J. Hall (*B.M.J.*, 1925. i. 110) who states that while attacking any part of the nervous system, the virus has a predilection for the neurons which are not yet organized and adjusted, and consequently the younger the child the more profound may be the result, depending partly on dose, and partly on the possible damage. Thus, a child below 5 years of age, but not later, may become idiotic. Where Parkinsonism develops, it is rare below 10. Other children are left in what he calls the difficult child group, the higher controlling mechanisms having been affected, and in the profoundest cases, many having been clever children, the animal propensities are unmasked in the Apache group.

Some of these children are pitiless and unemotional, others are irritable and develop aggravating habits, like the young child of nervous type previously described.

The virus remains for considerable periods, as relapses may occur weeks later. Improvement goes on in earlier symptoms, but mental changes are not easily got over.

Much conduct is uncontrolled reflex, instinctive, or automatic action of lower centres. The highest groupings concerned with morality (p. 414) which are yet labile and unfixed in childhood are easily thrown out of gear. Development is possible according to the child's age. The working out of this disease is a future problem of extraordinary interest. Re-education and emotional control by suggestion may do a little, but for comfort of the community many of these children must be in custodial care.

Some come under statutory provision for mentally defective children as "unable to properly benefit from education in an ordinary public elementary school," and at a later age pass under the Mental Deficiency Act 1913, as being "defective from an early age," and the defect is assigned as permanent.

Where parents cannot supply necessary control, transfer to the Guardians under the order of the L.G.B., 1911, provides for the child up to 21 years of age.

All who deal with these cases agree that even in comparatively mild conduct cases, removal to an ordered and quiet environment,

where they will be sheltered from conflicts and irritants, is the best chance for the repair possible to the damaged structures.

The only case that might cause doubt in school practice would be persistent or recurrent chorea, and fortunately the same treatment would be equally good. The history of the case and perhaps cardiac conditions would probably separate it at once from any doubt of being post-encephalitic.

Tics also may occur. They are more systematic in movement, and attention or distraction may prevent them. The recurrence, too, may be infrequent, and the history will be wanting.

Moral Ideas and the Moral Imbecile.—It would be an interesting study to trace the growth of moral ideas in the child and race. Development has been rapid in history since the days of

> The good old rule, the simple plan
> That he should take who has the power,
> And he should keep who can.

There are all kinds of morality, and different levels of ethical normality, in the community. The Englishman, the Jew, the Jesuit, the German, and the Quaker, all have a different ethic in life and commerce, of which their morals allow them to take advantage. Most newspapers still preach trivial personal advantages, and appeal to selfishness at election times as more desirable than is the good of others or advantage to the community.

The infant takes all, and gives nothing. The toddler cheerily wishes for its mother's death or some equally serious topic, regardless of anything but its momentary feelings. Before school age there is no real morality, save that of experience. "The burnt child dreads the fire." Abstract idea of law, appears late in school-life. When mankind comes into communities a development of moral sense is important. It is then seen to consist of rules and conventions, some highly artificial, for the good of the individual and the fellow he is in contact with. It is next extended to the family and "our class." The Public School boy learns to play the game with and for his equals. Then the fellow townsman is considered, so that we do not carry swords, as a previous generation had to do. Finally, it broadens out to the nation, and beyond that to the whole of humanity and by comparative sympathy to dumb animals. The noblest ideal and achievement of religion is to do unto others as you would they should do to you, only then is Liberty a possibility.

Morality consists of conventional and artificial conditioned reflexes that have to be learned by the child, and are the results of experience for the common good. "My duty towards my neighbour" may seem a meaningless gibberish when it is first learned, but the words remain, sink in, and in a few years it has a fundamental effect according to the individual's capacity. That is why

it should be taught in infant schools. The want of its ideals may easily upset a nation.

Morality, then, is a set of instinctive and emotional memories, conditioned reflexes stored up for habitual regulation of the various acts of life, and ideals developed in accord with the needs and desires of the community. Morality is a possession, the want of it a loss, a defect. Without the education which gives this body of memories and ideals, individual action would be selfish, egocentric, instinctive, and as a consequence antisocial. Antisocial conduct borders on delinquency and crime. Antisocialism in the long run means injury and harm to the majority of the community.

This was the position the writer arrived at from considering the problems in connection with other mental defects (*Birmingham Medical Review*, June 1905).

The speech and other centres dealing with the conventions of communications, are stations in a chain of nervous mechanisms. There are similar nervous mechanisms connected with moral conventions. They are not so obvious, being hidden behind the middle level machinery which carries on the ordinary instinctive and automatic affairs of life. They are also later in development and hence more liable to developmental variation than speech.

On this theory the necessity for mental defect other than the moral defect is unnecessary; and if no case of moral defect was known without mental defect, this would be a serious objection to its truth. Other attempts at explanation lead one into a morass of words, which deal with the vaguest intangibilities. Here we have some kind of a concept to hold on to, and if it works, to accept as suitable till a superior explanation emerges.

Moral defect, unaccompanied by any other defect, is here taken as, like word-blindness, a perfectly limited condition which is independent of other defect. The definition of Sir James Crichton Browne is therefore superior to that of the Royal Commission, 1908, or of the Mental Deficiency Act of 1913, in that it is clear.

"The moral imbecile is a person who, by reason of arrested development or disease of the brain, dating from birth or early years, displays at an early age vicious or criminal propensities which are of an incorrigible or unusual nature, and are generally associated with some slight limitation of intellect" (Sir James Crichton Browne).

Whereas the wording of the Act of 1913 is ambiguous: "Moral imbeciles—that is to say, persons who from an early age display some permanent mental defect, coupled with strong and vicious or criminal propensities, on which punishment has had little or no deterrent effect."

As moral imbeciles are not included under the previous headings of idiot, imbecile, or mentally defective, it is correct as it stands,

in that moral imbecility is to be taken as a permanent defect. It may be combined with other defects. The usual reading, however, that in addition to moral imbecility, expressed by vicious or criminal propensities, there must be other permanent mental defect, destroys the value of the definition. This incorrect idea has followed from so many of the cases with intellectual defects finding their way into courts or asylums, and from the Royal Commission stating that moral defect was generally accompanied by some limitation of intellect.

Educational training, whether natural or formal, may be warped or biassed by mental conflicts or complexes, but the essential quality of permanent defect in a moral imbecile is an inborn defect of neurons, which may be quite beyond therapy, is due to no complexes, and no education or analysis can affect neurons that functionally do not exist; although, as aphasic cases have shewn, education during the developmental period may have a stimulating effect and result in development of some function. Slight cases are therefore not hopeless at early ages.

The idea of such moral machinery is not new. Benjamin Rush of Philadelphia, in 1812, thought innate preternatural moral depravity due to original defective organization of the parts of the body which are occupied by the moral faculties of the mind.

Mercier, who originated the term moral imbecile, was an accurate observer, and had no doubt about moral insanity without any conspicuous intellectual defect (*J. Ment. Sci.*, 1894. 596).

Dr. Geo. Still notices eight out of twenty cases fully up to the average bright and intelligent children (*Lancet*, April 1902). Maudsley notes the possibility of a remarkably acute intellect with no trace of moral feeling.

Dr. Wm. Browning, from observation of cerebral injuries in association with moral changes, has attempted to locate a moral centre in the right frontal lobe, in right-handed persons, and in three cases in left-handed the injury was in the left frontal lobe. He concludes that loss of moral qualities can occur without loss of intellectual (*Med. Rec.*, 1921). He uses the term "morament" for this class.

Certain things would follow the acceptance of this idea of morality as a body of memories separate from intellectual qualities. For instance, intellect need not be related to morality, and history illustrates this in every age, before and since the days of the Borgias.

The educational appeal to the intellect, as in the case of instruction in sex matters, has nothing like the more fundamental emotional appeal.

Religion and politics are not matters of intellect, but of emotion for the majority of mankind. Effect on morality is through the feelings rather than the reason.

The idea of moral centres, late in order of evolution, has received

considerable confirmation by unfortunate results of encephalitis lethargica, where a child who has been developing in a normal way suddenly alters his whole bearing to life, and the lower appetites, emotions, and desires emerge in an uncontrolled way. The behaviour of the worst of these cases is that of a child without moral sense. Speech escapes damage, but the more conventional and later evolved morality is caught.

Where there is mental defect, any moral impairment will be of less importance in school, but where there is moral defect in an otherwise normal or even highly intelligent child, it may be the cause of much trouble.

Morality itself may get out of relation to intellectual or emotional balance, in some individuals who are punctilious and meticulous to a pathological degree ; or in others whose conduct in moral judgments, and want of sympathy, resembles that of a Grand Inquisitor ; probably these are merely functional, to be relieved by analysis. There are all varieties and degrees of the defect.

The first case encountered by the writer was an apparently normal little girl of about 10 years old, who occasionally did unruly things, which culminated in her breaking into school after closing time, and turning on all the water-taps. It was discovered that she always went one way home, where small children played on some steps, in order to get a chance of trampling on their fingers. Although she was healthy looking, neatly dressed, well cared for, and had a good home and upbringing, she was arrested next year for pocket-picking at a neighbouring fair and found with purses in her possession, thus confirming the diagnosis of moral imbecility grudgingly accepted months before.

A healthy and pleasant-looking boy, with curly red hair and freckled face, was pointed out by the head master as the cleverest boy in the school, but at the back of everything wrong—" although we cannot catch him, we know it." Some of the exploits were ingenious and diabolical, but it was always the cat's-paw that was detected. One of my notes describes a boy of 8, " Tiny boy of fair and angelic appearance, but moral imbecile of most hopeless and wicked kind, has attempted to drown a child. He never needs to be told twice to do a thing, and never asks a question."

A comparatively unknown official, without being seen, was diagnosed as a moral imbecile solely on his conduct during a single week, and although by his intelligence he raised himself in the next twenty years to one of the highest positions, his whole course confirmed the original opinion. Even to the end, colleagues who came into frequent contact with him, agreed in the early diagnosis of " moral imbecility, with an intelligence and ability approaching genius." He exemplified the description of Mercier. " Intellect includes more than mere intelligence, mere cleverness, the mere ability

to argue adroitly, to find specious and plausible excuses and explanations, mere smartness and verbal readiness, in which a moral imbecile may abound, does not constitute intellectuality, although it may constitute intelligence. There is a higher intellectual quality than this, a quality that I have called, appropriately, I think, wisdom; and in wisdom I mean that intellectual quality that guides and governs the higher and more comprehensive phases of conduct, that regulates the main business of life in adaptation to circumstances, that teaches us how to act, so that in the long run and on the balance, our lives will be successful; and in this quality, which is not only a mental but also an intellectual quality, the moral imbecile is always deficient. His life is always unsuccessful. However astute, clever, dexterous, intelligent his shifts and dodges and stratagems and tricks may be, he is always a failure in the long run. He may succeed in his immediate object. He often does succeed in his deceptions, his swindles, his lies, his forgeries and other crimes; but his success is very brief. Sooner or later, and usually sooner than later, he comes to utter grief" (*Practitioner*, 1917).

Fortunately, the numbers of the congenital moral imbeciles on a high intellectual level are small. They are generally verbalists, plausible and well spoken, but always with a loop-hole to escape. Their writings shew them masters of the *suggestio falsi* and the *suppressio veri*. Verbalism is almost a symptom. If of high-class intellectuality, they will work assiduously, and may contrive wide and complicated mechanisms and arrangements, out of proportion to the purpose to be attained. Their schemes are generally failures in the later working, the organization being more important than its purpose. For a time the deviser, regardless of fear, without sympathy, compassion or pity, pursues a triumphant course of little benefit to any but himself, until failure looms ahead.

The earliest signs may be examples of perverse cruelty, as exemplified by the little boy who buried rabbits in the garden with only their heads protruding. By 5 years old, lack of affection for parents or gratitude to those about them will be noticeable. In any case, if education to moral ends is to have a chance, slender though it be, it must be exerted in the earliest growing period. Possibly in early years the moral development may be simply retarded. On the other hand, age may just increase their skill and cunning, and add to their evil instincts and malignity.

The marked moral imbecile, who is probably incurable, should be recognizable by the age of 7 or 8. Most should certainly be recognizable, or at least suspected, during primary school-life. In Circular 1359 the Board of Education think that in view of Section 1 (*d*) of the Mental Deficiency Act, 1913, it is only in rare and exceptional circumstances that a child of school age could properly be certified as a "moral imbecile." The moral imbecile

is rare enough, but if at all pronounced, so as likely ever to need notification, should in the majority of cases be recognized at school age, whether certified or not.

Their failure may become obvious in the stress of puberty. If till then there has been no indication, it is a chance that dementia præcox is appearing. This is a condition of steady degeneration in comparison with the stable congenital moral imbecility. Many are normal in appearance, healthy, jolly-looking youngsters, of whom one would think no evil, although G. F. Still noted some of them as sullen-looking.

There are grades and varieties, from the clever scholars who may become peeresses or millionaires, to the unstable neurotic who may become a murderer. The clever ones are not caught in school or in later life. Their characteristic is that they know no regrets, shame, or contrition for their misdeeds. When they acknowledge and excuse them the emotional indifference is prominent and striking; they do not realize the position.

For the intellectual ones knowledge and languages are weapons. They should be carefully recorded by description and finger-print filed for future use. A suspicion of moral imbecility should lead to such records.

The imaginative lying of a young child means little. Imagination may be brilliant, and eidetic imagery is so clear that the pre-school child cannot always be blamed if it confuses imagination and reality. Sometimes a child describes misdeeds it has never committed. The pathological liars are those who make accusations, not to save themselves from blame or for mere romance, but who apparently without motive and without benefit will weave a web of the most intricate detail about their neighbours or relatives. In some cases the untruth is proved easily, in others only after thorough enquiry. They are frequently precocious, and of the attractive, insinuating type.

Whatever child makes a charge, it should not be accepted without corroboration. The child making false charges usually does so in a cool, unemotional way, is drastic and thorough in the statements, and adheres tenaciously to them till the *dénouement*, and then has nothing further to say, and expresses no apology or regret.

On the other hand, the mentally defective child is so suggestive that it can be readily made to contradict itself flatly by cross-examination in a leading way.

In children, then, pathological lies are, as it were, essays in the deception and swindling of later life. They should be definitely catalogued as affording strong suspicions of moral defectiveness.

Stealing or thieving, as a permanent condition in children, apart from environment, is another symptom of moral defect. It

may also be the result of some, often sexual, subconscious repression, finding its way to light, and is a common symptom of beginning degradation after an attack of encephalitis lethargica. If, in addition to these delinquencies, a fairly high I.Q. is found, it is rather in favour of some repressed influence at work.

Truants and Wanderers.—Truancy is a natural reaction of the child against artificial life and unhealthy conditions of school. The truant is either drawn away by desire to escape pressure of his surroundings, for exercise, fresh air, natural education from the birds and beasts. Perhaps he is driven off by boredom of lessons he does not understand. They are above his mental level, or he has some difficulty of hearing or seeing, or there is some other unpleasant condition. Absentees, with a note from home, are often a neurotic variety with a nervous mother.

The runaway or wanderer who seeks a new life may have the normal desire to do things for himself, for there are about four boys to one girl, who put forth in this way. "Over the hills and far away" rings in his ears; he starts to seek fortune in the town, or runs away to sea. These, as a rule, have a definite reason. They have planned it out, and at an appropriate time go off. Two children ran away last Autumn leaving the pathetic note, "We are going because you are so poor," but this was not pathological.

In young children control of the desire is not yet fully developed, they are without good judgment, some momentary happening or emotional outburst starts them off. They may follow a circus, or run away from punishment, or a stepmother.

The fugue is a short reaction of a psychopathic child, but scarcely pathological, merely immature. Control has been upset by some emotional disturbance, and for a time life goes on automatically and subconsciously. It is not the result of reasoning, or definite aims for the future, but merely some subconscious urge, which is thus relieved.

It may be an immature expression of vagabondage, which is a reaction of the socially unadapted to life. The vagabond is usually a moron, or if, as one hears occasionally, he possesses a Greek Testament or a well-thumbed Horace, then he is an early or arrested case of dementia præcox. These are unequal to the burden of civilized existence, and sink to the simplest level they can reach, almost animal vagrancy.

Attempts to escape from residential institutions are nearly normal reactions, and condemn the institution more than the child. Still, there are other cases, some no doubt the expression of complexes, or the sense of inferiority, which an analysis might reveal.

For several years the writer heard of the young son of a colleague who would disappear for days, till a telegram from Ireland or Scotland would arrive that the police had found him. He appeared healthy

in every way, and came of a wholesome stock. He would resume school, not knowing why he had been away, and a month or two later it would recur. These were fugues in a neurotic boy, but the underlying, subconscious cause was never ascertained.

Another youngster of about 9 would escape from school or from the house if not watched, and turn up at a vegetable market a few miles off. He generally came into the hands of the police, and whenever interrupted in his wanderings, always said the same thing, "I want to buy a fish." An automatism was at work.

After an epileptic attack, the post-epileptic condition of exhausted higher centres may result in automatic wandering, the individuals not knowing what they are doing. They may go on day and night for hours in an irrational way, till they recover slowly. The slighter form is exemplified by the child walking out of its class, but these others may go on for a dozen hours, by road, train, or otherwise.

Some of the cases seem like double personality, and are of a hysterical nature. Although the writer has never seen such a case in a child, it was not uncommon in invalids from the War, but the tendency gradually wore off.

Any case of this nature, shewn in fugues or wandering, will have to be considered, not as a delinquency for punishment, but as a pathological symptom for enquiry into the root cause, the discovery of which will probably mean relief.

Delinquents.—The nature and problem of the delinquent child should have been realized from the preceding pages. It may be a trivial affair arising out of the natural trial and error methods of adjustment to life, it may be artificial, like the Cambridge crime of "playing marbles on the Senate House steps," or it may be a delinquency which has definite and far-extended causes, and is not to be considered accidental. We are all at times delinquents in some measure, but only a few are found out. The chief cause of detection is want of intelligence. The master criminal is too clever to be caught except by accident. The definition is so various that child delinquents are reported 4·9 per 1000 children in New York, 3·6 in Chicago, 16·2 New Orleans, 17·8 Seattle, 21·3 Philadelphia, and 38·8 Richmond, Va. So that figures mean almost nothing for comparisons (1922).

In the child delinquent varying degrees of feeble-mindedness, emotional want of control, moral weakness, or bad education of too low ethical standards in the environment, may be combined in such differing degrees that a great variety in delinquency occurs. The purely psychological factors have been detailed by Burt in *The Young Delinquent.*

One sentence from the last Report of the Prisons Commissioners is noteworthy in that it is "rare for a lad or girl to be received into prison who has been a member of a good boys' or girls' club, a Boy

Scout or a Girl Guide, or a member of the Church Lads' Brigade." This simply indicates that the individual who has social qualities is at once removed from the large class of artificial crimes against social conventions, such as property and so forth.

As shewing the prevalence of feeble-mindedness, the study of 215 boys of a Californian school made by Terman and Williams is representative of a mixed collection of young delinquents : 64 per cent. white, 15 per cent. negroes, and 21 per cent. Indians. The relatively high percentage of Indians may indicate educational results of ideals different from those of the average civilized person. The mental and chronological ages are set out in the figure, shewing a mental retardation of about 4 years, the mean of each being shewn

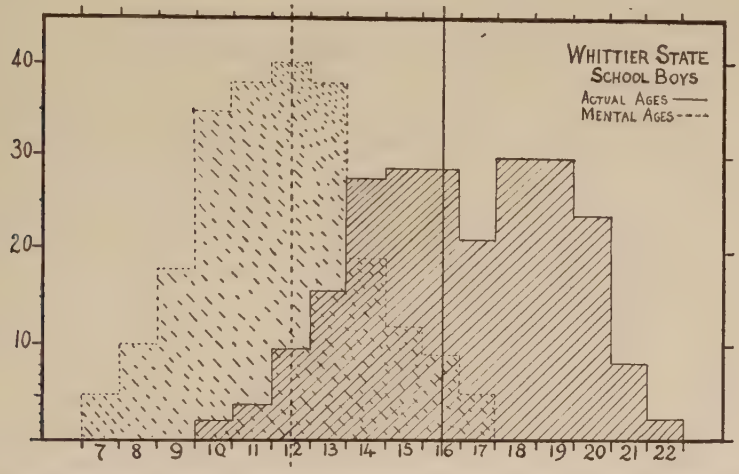


FIG. 82.—MENTAL AND CHRONOLOGICAL AGES OF 215 REFORMATORY SCHOOL-BOYS TESTED BY WILLIAMS AND TERMAN.

by vertical dotted and continuous lines. Their other measurements approximated to normal, except that heights were a little shorter. Mental retardation must not be over-estimated, as their nearest stratum socially, recruits during the War were estimated on the same basis, as about $3\frac{1}{2}$ years retarded in intelligence. Only 9 of the 215 boys had reached normal standard in school, and 32 per cent. were definitely feeble-minded, 21 borderland, 27 dull-normal, and 20 per cent. normal or superior in intelligence.

As regards heredity and environment, Dr. Mönkemöller, in 1909, investigated origins and social surroundings of child criminals in the Province of Hanover. There were 603 cases under 12 years of age, and 456 were sent to prison. Of these 101 came from small villages, and 196 from country districts.

Conditions of their parents were shewn by mental disease 39, feeble-mindedness 47, nervous disease 45, not including 25 epileptics ;

312 were drunkards, and 90 had phthisis. In their social relations 15 had attempted suicide, 288 had been previously convicted, and 95 were known to be supported by prostitution.

The social conditions of the children were indicated by 106 who had had brothers or sisters convicted, 122 were illegitimate, 195 had parents dead, 63 parents separated, 17 parents divorced, 32 father deserted, 215 extreme poverty, 145 step-parents, 23 parents were wanderers, and in 346 both parents worked away from home.

The physical and mental condition of the 456 convicted children may also be assessed, as 120 had only walked very late, 239 were habitual bed-wetters, 13 of the girls were no longer virgins, and 224 were mentally abnormal, including 166 congenital mental defectives, 55 nervous, and 88 mentally abnormal.

Education by natural environment has powerful effects. Wretched housing, absence of ordinary conditions of decency and opportunities of cleanliness and self-respect, unemployment, poverty and hunger, sharpen the child's instinctive appetites and drive it to thieving, lying, and trespass. Where intelligence is poor, and nutrition impaired, defective control accentuated by these factors almost certainly brings the child into care as a delinquent. Here is a child of 7 charged in London (April 23, 1925) and stated to be well known to the police since the age of 4.

The Law is careful of the child. Nearly a thousand years ago Athelstan ordained that a child should not be treated as an adult for a first offence. Yet in this country within living memory, in 1833, a child was condemned to death for breaking a pane of glass and stealing twopence worth of paint. The Children Act of 1908 laid it down that a child shall not be sentenced to imprisonment, or a young person to penal servitude or imprisonment, unless the court certifies that he is of so unruly a character that he cannot be kept in a place of detention, or of so depraved a nature that he is unfit to remain there.

When a child comes under cognizance of the Law it is chiefly for safety or protection, or as a juvenile offender for misdeeds. The police may remove it to a place of safety until it can come before a court of summary jurisdiction; meanwhile it must not be brought in contact with older offenders.

Legally, by the Children Act, 1908, Section 131, a child is a person under 14 years of age, a young person is 14 years or over and not over 16; beyond this they are no longer considered children or young persons. The age is reckoned at the date of conviction. For the purposes of the Education Act, 1921, Section 170, "young person" means a person under 18 years of age, who is no longer a child, "child" being any age in which school attendance is compulsory. In America, in about a third of the States the jurisdiction of juvenile

courts extends to 16 years, in another third to 17, and in the rest to 18 or more.

Section 111 of the Children Act states that a court where a child has to appear, unless the child is charged jointly with an older person, must sit in a different building or room, or on different days and hours, to its ordinary place, and under these conditions is referred to in the Act as a juvenile court. The court may remove the child from its home surroundings, or keep it under observation, or entrust it to a fit person, or send it to an industrial or reformatory school. The machinery of the juvenile court appears a cumbrous process, and for practical purposes all it does is decide whether a child has to come under care and, if so, approve of the proceedings of the Education Authorities. Its abolition, however, is not desirable, as in the future its proceedings may become important in such a matter as sterilization, and at present it has many duties in regard to custody, guardianship, and matters not of a medical nature. It is of much greater value than, for instance, the coroner's court.

The industrial school is an educational institution for benefit and not discredit of the child. The ideal is to work it on the same lines as ordinary school. A child under 8 years old may be boarded out, and attend the elementary school, instead of sending it into the industrial school, this practice lasting till 10 years of age or longer. A child may remain at the industrial school till 18 years of age. A first offender, if over 12, may be sent to an industrial school. In 1923 about 5300 boys and 1500 girls were in industrial schools.

The reformatory school is a penal institution. It is for the industrial training of youthful offenders, and they may be kept there until 19 years of age. An offender from 12 to 16 years of age may be sent there instead of to prison or other punishment. In 1923 there were about 2500 boys and 200 girls in reformatories.

The court order may be made out for an industrial school where special provision is made for those with mental or physical defects, as ordinary reformatory and industrial schools will not receive defectives. Until such a place is found the defective can be sent to a remand home or place of detention.

Police officials will deal with these cases, except in educational matters or in respect to the Mental Deficiency Act, where the school doctor may have to examine and report to magistrates on any case. Most magistrates require the story told slowly and clearly, the doctor must have all his facts as to the child's condition and intelligence, and any deductions, set out very plainly and simply in reports. Many cases coming under remand will repay prolonged and detailed examination, and here and there among the unstable, and those of apparently normal intelligence, all kinds of complexes and impulsive or compulsive influences may be elicited. The right time for modifying the nervous child, with its faulty habits or over-

powering complexes, is in the habit clinic, at as early an age as possible. The child who reaches puberty is unlikely to alter the grooves of its life except under long-continued and powerful direction. Some, indeed—those, for instance, of mentality equal to IX years—will not be safely prevented from delinquency unless in custodial care throughout life. Re-education or cure of any kind must be in the plastic age, or it becomes so impossible that it is a mental miracle.

Mönkemöller's enquiry makes evident a criminal stratum circling round from generation to generation, and being regularly recruited. Crime or criminals breed crime and criminals, and this is the chain that has to be broken. Whether the optimism of some psychologist-criminologists will be in any material measure justified it is not possible to say, but no doubtful cases should pass out of court until thoroughly investigated. Dr. Auden, from careful enquiry of cases in the Birmingham Remand Homes, thinks all child cases should go to an institution for intensive examination ere appearing in court; the mental make-up of the child will then be in evidence. From experience of older prisoners, Dr. Hamblin Smith considers 15 to 20 per cent. are delinquent as the result of mental conflicts. Dr. Shrubsall has made a very extensive study and comparison of English and American methods (*L.C.C. School Med. Off. Report*, 1924 and 1925).

There may be tendencies to waywardness just before or about puberty, and this is perhaps more evident with the girls. It is not only inexperienced or feeble-minded who take to downward paths; even those more mature and of high intelligence, but of unstable and emotional temperament, are suggestible, and easily led to immoralities. The feeble-minded are as suggestible and have not the knowledge or intelligence of these others; hence they deviate very easily.

Of 432 girls noted at the State Training School at Geneva (Ill.), it was estimated that at least thirty would become well-behaved citizens. The majority had immorality linked with the cause of their commitment.

Dr. Shrubsall notes Immorals coming under consideration of the Mental Deficiency Committees (*School Hygiene*, 1921. 130). Table 60, of course, is a selected group, and more would have appeared in the last five columns had they not escaped the Mental Deficiency net.

With many of these girls careful handling is wanted, preferably by a woman doctor. They are often temperamental or hysterical, full of lies and accusations. Definite disease may have to be ascertained or excluded by microscopical or other tests.

In inspecting residential institutions all the general rules must be followed. The writer has found reformatory girls working in a

large room under an average artificial lighting of less than 1 foot-candle. The case is mentioned below where boys suffered who got access to polluted water used for washing floors.

It is advisable to maintain medical inspection cards and record all accidents. It would conduce to develop self-respect in pupils if they were made to keep their own records of physique.

The fundamental rule of education of attaching pleasant and enjoyable values to right kind of action, and making wrong things little valued, and of colourless or unpleasant emotional content, is valuable, and all unnecessary rules of silence, or prohibitions of activity, to be reprobated. Responsibility is to be given. Youngsters must lead healthy lives of both physical and mental spontaneity, and be as unrestricted as possible, especially about

TABLE 60.

249 IMMORALS UNDER MENTAL DEFICIENCY ACT (SHRUBSALL).

Actual Age.	Mental Ages.									
	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
14 or less	—	1	1	—	1	—	—	—	—	—
15	—	—	1	1	1	1	—	—	—	—
16	8	41	39	—	42	—	19	—	—	—
Over 16	—	—	—	62	—	18	—	8	5	—

puberty, when life adjustments are made. A superintendent who insists on silence is, as a rule, unfit for the position.

Diets require careful supervision by the school doctor, as there may easily be a dangerous economy, especially as to vitamin content. Outbreaks of disease occasionally occur which seem related to want of immunity, possibly also due to some degree of avitaminosis. Several outbreaks are recorded, with some fatal results, from different varieties of pneumonia. In one instance, which the writer had to observe, many cases of appendicitis needing operation occurred within a few weeks, and some were fatal. No cause was determined. The Brentwood school referred to above had over two hundred cases of mild typhoid from forbidden water being used for drinking, taken up in buckets in a cellar from a stream, instead of using the water-taps which supplied potable water upstairs.

Acute contagious ophthalmia becomes almost chronic unless energetic measures are taken in an early case; the very measures themselves may easily keep up ophthalmic irritation when the infectious danger is past. It is fear of this disease that makes it safer to have washing sprays instead of hand-basins in these residential places.

Sterilization as a Social Remedy.—There are family stocks distinguished by high intelligence and great achievements of their members. The first volumes published by the Sociological Society afford examples, and Sir Francis Galton was himself representative of such a family.

One soon learns of families at the other end of the scale in handling the feeble-minded children. These families, from want of intelligence, are struggling along in poverty, hunger, dirt, and disease. They have many undesirable dependents below the standards of community life—paupers, drunkards, prostitutes, beggars, thieves, and criminals ; they are scarcely of the community to which they contribute troubles.

Idiots may occur in any social stratum, but are of the character of "sports," or are disease products, and from their nature of no importance as regards the racial future.

Imbeciles are of account; the congenitally feeble-minded, morons, the moral imbecile, and certain classes of criminals—these are dangers to the common good, and all tend to reproduce their kind.

Twenty years ago the social relations of mentally defective families were compared with normal ones.

The families of a hundred feeble-minded children in special classes, and a normal hundred selected by every seventh name on the register of the schools which contributed the feeble-minded, were investigated by Dr. Ettie Sayer (*L.C.C. Report,* 1906. 42). She noted 34 per cent. of the feeble-minded children as having one parent distinctly defective. The average normal family numbered 5, the feeble-minded family 7·4 each. Her results are summed in the table.

TABLE 61.

Children (100 Families of Each Class).	Number of Children Alive.	Other Children in Family M.D.*	Imbecile.	Number with Active Tubercle.	Dead.	Assigned Cause of Death.			Stillborn.	Miscarriage.	Total.
						Specific Fevers.	Convulsion, Teething.	Other Causes.			
Normal ..	387	0	0	2	84	33	19	32	12	23	506
	76%				16%	39%			2%	4%	
Defective	467	24	4	10	176	26	48	103	17	101	761
	64%				22%	14%			2%	13%	

* Does not include the selected school child in each case.

The parents themselves were tabulated, as given in Table 62.

A satisfactory record of some feeble-minded families is difficult to get, as only striking facts are known. Indeed, one mother told

the writer that she had had two girls, "and there's been a lot of little boys," but she did not know how many. The contrast with the complete records of normal families is striking as a proof of intelligence.

Dr. George Ordahl (*Training School*, 1919) measured the B.S. Scale intelligence of at least one parent and one other child in the families of 50 feeble-minded American children. He found, among 50 mothers, 16 morons, 11 dull-normal, 5 psychopathic, 2 dead, 1 unknown, and 15 normal. Of 30 fathers tested, one-third were defective. Of 219 children born in these families, 59 are dead. The living have 5·6 per cent. idiotic, 15 per cent. imbecile, 26·2 per cent. moron, and 48 per cent. normal.

E. A. Doll published 13 pairs of feeble-minded siblings in the Vineland Institution. Goddard, in his book, *Feeble-mindeness*, p. 472,

TABLE 62.

Parents.	Mental Deficients.	Insanity.	Suicide.	Epilepsy.	Alcohol.	Consumption.	Other Causes.	Poverty.
Normal child—								
Parents	2	—	—	—	6	3	18	4
Family history ..	—	7	2	6	1	36	21	—
Defective child—								
Parents	34	2	2	3	42	13	27	40
Family history ..	3	29	5	8	7	53	18	1

says Vineland children represent 327 matings with 1776 children, of whom 585 are defectives, 401 normal, 39 doubtful, 275 died in infancy, 225 were miscarriages, and 251 unascertained.

The Jukes family, worked out by Dugdale, were the five daughters of a ne'er-do-well fisherman born in 1720. In five generations, including those married into the family, were some 1200 persons, of whom 540 were well known and 500 partially known; 300 died infants. Of 900 there were 310 professional paupers who had spent 2300 years in workhouses; 440 were physical wrecks through their own misguided lives, more than half the women being prostitutes. Convicted criminals numbered 130, and there were 7 murderers. These persons were estimated to have cost the State 2,500,000 dollars, and their expense still grows.

Perhaps the best wide-range illustration of the heredity of feeble-mindedness and its comparison with normality is the Kallikak family recorded by Goddard (MacMillan, 1912), traced back from a girl in Vineland. During the American Revolution, Martin Kallikak,

a young soldier of good family, found a partner in a tavern, a feeble-minded girl, and by her had illegitimately a feeble-minded son, from whom 480 individuals descended. Four-fifths of them feeble-minded, epileptic, or criminal, the women immoral and often prostitute. Goddard classed 262 as definitely feeble-minded, 197 normal, and 581 undetermined or doubtful.

In 1779 Martin Kallikak married one of his own social class, a Quakeress, from whom were 496 descendants, who have mostly become useful, respected, and intelligent citizens. A few were alcoholics, but none were recorded as mentally defective. The beginning of these two descents from the same father, but on the left a mentally-defective woman, and on the other side a normal woman, can be shewn. Even if considerably discounted on suppositious possibility of errors from personal equation, the results must remain a striking illustration of degenerate heredity.

It is noteworthy that whilst the offspring of the eight normal children numbered 496, the one mentally defective half-brother in that period had 480 descendants.

From Goddard's records the figure has been compiled to shew the feeble-mindedness. For clearness, all other information as to descent has been omitted, but the individuals are in their order of succession as given in the original table. For the sake of space, the later generations are omitted.

Goddard regards congenital feeble-mindedness as a Mendelian character. This is doubtful; sometimes it seems recessive. An apparently normal girl will transmit the defects of a parent to the grandchild. Sometimes, again, defect seems sex linked, e.g. six boys in a family were affected whilst the three girls interspersed were normal healthy workers. It is probable that it is not of simple nature, but that several factors are concerned. The fact of its hereditary nature is indisputable, whatever the exact mechanism may be.

Feeble-minded matings with feeble-minded are noticeable. Goddard states that there are 41 instances among the Kallikaks, and they produced 122 feeble-minded and only two normal children. For the last there are several explanations, or they would contravene his theory of Mendelian dominance.

Lady Leslie Mackenzie, from her Scottish experiences, writes: "The feeble-minded young girl who becomes the mother of illegitimate children lives her life between the poor-house and the streets. She brings forth her children, most probably feeble-minded like herself. She is thus a known cause of race degeneracy, and she is increasing the very grave social problem of the unrestricted breeding of the unfit" (1924).

There should be no illegitimate children, they are all legitimate in the Laws of Nature, but there are illegitimate matings. A notice-

able feature in my own experience has been not the illegitimate births, but the frequency with which the feeble-minded girl is married, compared with the boy.

In an enquiry in London Special Schools in 1913 the children had 21 uncles and 27 aunts in special schools, and as boys are five

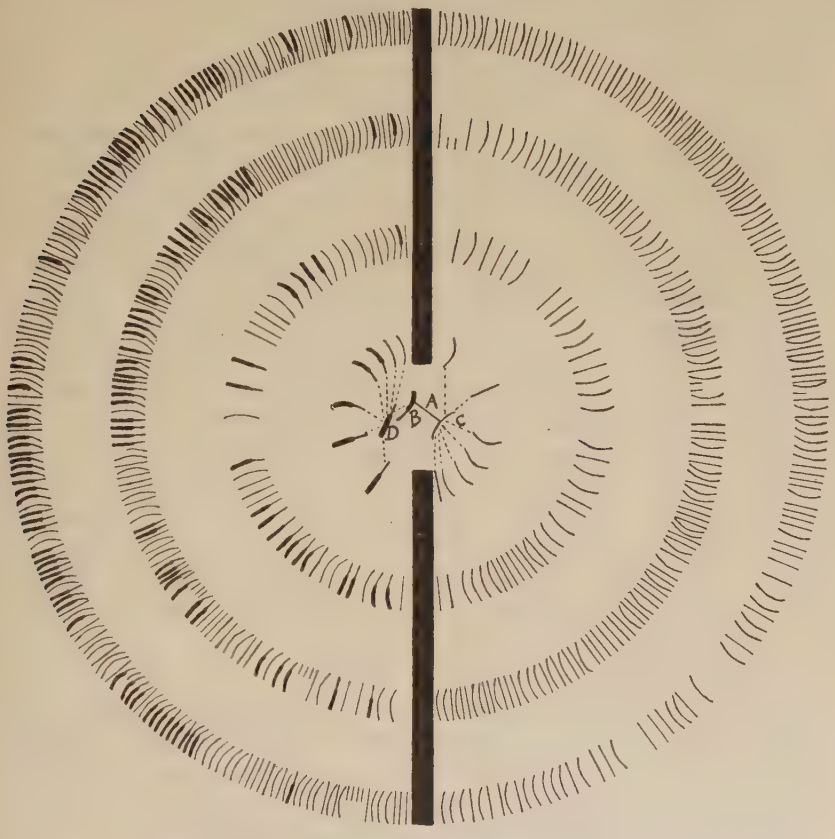


FIG. 83.—FIVE GENERATIONS OF THE KALLIKAK FAMILY.

Males straight, females curved. Feeble-minded thick black. A, the original Martin Kallikak; B, his feeble-minded partner; D, her feeble-minded son, from whom on the left hand many degenerate descendants; C, the Quakeress wife, from whom on the right a mentally normal stock.

to girls three in the schools, it points to the sisters of feeble-minded children marrying more readily than brothers.

The high-grade moron often presents herself as a simple, smiling, affectionate, and apparently very innocent girl, but this is evidence of weak emotions and an innocence that springs from mental poverty.

For the purpose of this discussion the cases of mental defect or arrest resulting from accidental causes or intercurrent disease are

left out of account, and only congenital or hereditary cases considered. Where there is any doubt a case should be considered hereditary. These people have not the sense to fit themselves into the structure of civilization. They are inadequate as citizens. They do not render service enough to pay for their support. They resort often to selfish means of lying or thieving, or offend in other ways, and may prey upon the community. The failure of the law to make them play a satisfactory part is obvious.

It is desirable to eliminate such hereditary elements from the population. This is a thoroughly artificial end, as Nature knows nothing of civilization or its conventions. The original left-hand generation of Kallikaks lived a healthy country life like animals. The 10 children of Martin Kallikak junior numbered 2 dead in infancy, 1 lost trace of as a man, and 7 others, of whom 3 are recorded as " very old," and the other 4 averaged 91 years at death.

If the community is to be protected in the future the vicious circle of heredity must be broken in each case. Most effective is to snap the link between generations. Unfortunately, ideals developed out of traditions built up on the science of scores of centuries ago still oppose action for the common good.

When asexualization before the feeble-minded reached the age of twelve years was proposed for all congenitally feeble-minded who had been two years in special schools, there was a silence in the Royal Commission which could be felt. Yet this is the only logical treatment and will be adopted as the most effective scientific method to put an end to a great part of the future sociological risks.

It is only to these risks that it is applicable, as the particular individual may still need supervision and perhaps custody.

For the past twenty years Miss Dendy, from her Manchester experiences, has advocated segregation. The elaborate provisions of the Mental Deficiency Act may be taken as indicating that the only means sanctioned by law for preventing the propagation of the unfit consists in their segregation in licensed institutions.

The Vineland work is based on permanent care. Segregation as a protective measure is costly and partial, from the point of view of future offspring. It also means that numerous individuals often strongly developed in particular respects are restrained from what to them is a main normal satisfaction in life. This would be avoided by castration, but simple sterilization is purely a community benefit for the future, reducing risks to zero. To say that these defectives will spread disease is trite. They do it now as much as they ever will, and it is curable. Here the question of morality is of quite negligible import.

Birth control is advocated by many as a remedy for the regulation of our ill-adapted social system, but no birth control is worth consideration that does not begin with those most needing elimination.

Eugenics, until elevated to a religion, will be so trivial in effect that for those below the average it does not count.

In face of daily experience, and such records as the Kallikak partner, it is nonsense to listen to theoretical statements of the hundreds of generations required to breed out recessive traits. For practical purposes the strains will always crop out. A bonus of five pounds compensation for every case treated would probably bring from the social strata most needing regulation more candidates than could be dealt with for a long time, and be repaid a thousand times in the saving to the future.

A beginning could well be made in hereditary cases of mental disease, by sterilizing all of later generations who have to come under care in institutions, this, of course, being merely a beginning to familiarize the idea.

Segregation will be evaded in most cases. Congenital feeble-mindedness will not be stamped out, but the results of sterilization will shew in the drop in rates and taxes within the lifetime of those who carry out and popularize the measure.

It requires clearly presenting as the only economical remedy for insane, epileptic, defective, and criminal heredity; a certain break in some of the many vicious circles of crime and defect.

If community interests are placed above individual, in the way they were when both coincided ten years ago, and it is made a crime to be feeble-minded, the law can as simply and justly prescribe sterilization as it now orders execution for murder.

It is easy to ask frivolously where to draw the line. An odd case here and there might be included which also might have been exempt, but probably it would be wholly to the advantage of the community if any doubtful case were included. No law will ever include all who ought to be subjected to it. Only the worst half, or perhaps quarter, will ever come into consideration under the provision. The court would decide whether a case was congenitally feeble-minded or not, and after that order would be made and the law take its course automatically. Appeals and further processes of law should be made costly and difficult in these cases.

The law passed in many American States remains almost a dead letter. It might yet be found wanting in legality, and the public conscience is not aroused to put it effectively in force. An executive officer should be specified whose special duty would be to carry out any law of this kind. The coroner would be an appropriate person. Lord Riddell (*B.M.J.*, 1925. i. 842) holds that under English law sterilization in the male was illegal, amounting to maiming. For the female, if healthy, it was illegal, consent or not. In the case of feeble-minded, sterilization would be illegal, unless for the benefit and welfare of the patient.

The British Medical Association (*B.M.J.*, Supp., 1925. i. 286) took the opinion of Sir Travers Humphreys, who thought the operation, however excellent the motive, illegal, unless necessary for the health or well-being of the patient. It would be "unlawful wounding" under Section 20 of Offences against the Person Act, 1861, or ill-treatment under Section 55 of Mental Deficiency Act, 1913, or "assault" and "unnecessary suffering" under Section 12 of the Children Act, 1908. No indemnity could provide against the illegality, save that in an epileptic of mature years clearly giving consent before the operation would be sufficient answer to any charge.

Eugenics or education as a means of arresting defective germ plasm is hopeless because it makes no effective appeal to feeble-minded who do not understand. Legislative prohibition is also futile. It does not prevent incest and illegitimacy. Segregation to this end is costly, partial, restricted, and at the best but a stop-gap in a few cases. The only certain remedy is sterilization, widely applied. Segregation can never be effectively applied, owing merely to its cost.

The whole subject of heredity and of asexualization as a social protection requires ignorance and false sentiment dispelling, and the law amending, if the increasing plague of those born defective is to become manageable or be stayed by the only rational means in the power of the community.

After-care.—At 16 those requiring custodial treatment should be reported to the Control Committees. For the others some kind of after-care is generally needed.

One thing is now evident, that an enormous amount of time and effort is expended on useless attempts at education of mental defectives.

It is folly to spend on these hopeless, wastrel products, who will make no return, as much, in many cases a great deal more, than on superior children who have everything to yield as a profit to the community.

Estimates of working capacity of the moron are optimistic beyond justification. The best judgment that can be made is, how many should be kept under daily supervision in an institution, and how many be permitted to mix in the community. For this last, one-third of all would be an extravagant estimate, and of these one-half may just float along, contributing enough to supply their wants, occupied in simple mechanical pursuits, box-making and such occupations. Even then they pass from place to place. It would be difficult to find half a dozen morons who had been out of a school for a couple of years and had been in the same situation twelve months. For the other two-thirds institutional cases perhaps half will contribute materially to the cost of their

support, but it will have to be in ways where all the intellectual processes have already been arranged by others. They will be able to dig fields, saw wood, feed pigs, carry manure, and do such agricultural occupations as others may direct. Their life should be custodial care in an industrial colony.

The question regarding each pupil on attaining the special school-leaving age arises : Is this child fit to be allowed to mix with the general community ? Unless definite evidence of fitness is forthcoming he should be automatically reported to the Control Committee with a view of being drafted to a colony.

In the first annual Medical Report to the London School Board in 1903, one-third of the mentally defective children in an examination made for the purpose were decided as requiring an after-care supervision, and one-third as only fit for custodial care, but that was discounted as too optimistic. Many who can contribute materially to their own support would be better under permanent custodial treatment.

In 1908 a card record of their working prospects was made for 4844 (2862 boys and 1982 girls), aged from 6 to 16 years. One-fifth, or 19 per cent., were estimated as more suitable for an intermediate school, 73 per cent. as likely to improve, 70 per cent. to earn a living, and 19 per cent. to contribute something to their own support. Unfortunately, the special question of future custodial care was not recorded. Here again at the time the figures are said to err on the side of optimism. It should be said about the 19 per cent. " more fit for intermediate schools " that the estimate was made before the B.S. Scale had come into use. Hill, in a recent paper (*Science Progress*, 1925), states that 4 per cent. now return to ordinary schools. Where good results educationally are recorded from special schools, it is generally from a small class which includes a few retarded cases wrongly diagnosed, or doubtful pupils sent there through the personal equation of the examiners. In the Bristol special schools in 1920, as the result of intensive work, Dr. Stocks decided that 8·7 per cent. were not more than 10 per cent. below the average, and only assigned 11 per cent. as definitely feeble-minded.

When the figures of the London After-Care Association are examined, the same factors noted in 1908 emerge. In 1921, of 4134 born in 1901 or subsequently, who had left special schools, 31 had died and 325 had not been traced ; 712 were judged employable but out of work owing to the industrial crisis ; 462 were in blind-alley precarious work. The remainder are catalogued under various heads, but reading between the lines the returns shew that two-thirds are not capable of keeping afloat by their own efforts in adult life.

Dr. Shrubsall deems those of age VII unemployable, but those

over age X, unless unstable, are fit for life in the community. He works out a regression equation for London special schools—

$$\text{Mental age} = 0{\cdot}454 \times \text{chronological age} + 2{\cdot}08.$$

If the average age of reaching the mental limit is 15—and really this is too high—the equation gives an average age IX for the London special school leaver. Shrubsall's valuation for the 6900 children recorded was—

Chronological age	7	8	9	10	11	12	13	14	15
Mean mental age	4·92	5·66	6·36	6·91	7·20	7·79	8·35	8·67	8·26

Birmingham has had an After-Care Committee for twenty-five years past. They report that of those aged 14 to 40 who had been in special schools, 691 out of 1903 males were doing useful work, and of these 24 were soldiers. Of the females, 336 out of 1327 were usefully employed. 306 males and 219 females were lost sight of, and 124 males and 72 females dead. The rest had been dismissed as incapable for work, or were at home doing nothing, or in institutions. In 1923 this Authority reported to the Board of Education that only 30 per cent. of special scholars were employable at 16 years of age.

In Hull, of the 198 discharged from special schools, wages and occupation fell off with age, even in such precarious jobs as they obtained. It was decided, "of the 185 surviving it is practically certain that 170 will sooner or later have to be maintained at the public expense, as has already occurred with 54 of them, who are in Institutions, as well as the number unemployed who are in receipt of relief under the Poor Law." Dr. J. W. Fraser followed out a large number in Hull, through school-life, and decided that if the I.Q. was over 50 and an annual mental age gain of 6 months had been maintained, and they were permitted to leave at 14 instead of 16 years, unless they showed anti-social qualities, they had a prospect of succeeding in floating along in life. Out of 131 followed out, 7 per cent. were earning enough to keep themselves, and a very liberal estimate of the number capable of maintaining themselves would be 17 per cent. (*B.M.J.*, 1925. i. 1102).

Three of the schools for elder mentally defective scholars in London were catalogued by education officials only, as regards those in the first three years after leaving school. They found 65 per cent. in employment, and about 10 per cent. employable although not working. The final estimate was that 80 per cent. were employable. Although the scholars of these schools are specially selected as being trainable, and it is also based on the first three years, as an estimate of adult working capacity this is absurdly optimistic, and cannot be admitted as a correct judgment.

Since my 1903 Report that one-quarter of the mentally defective

children in special schools needed custodial care, it has been steadily impressed by experience that the majority need constant supervision through life. Education is wasted which is not directed to their aptitudes, generally limited to the production of the simplest useful mechanical actions arranged by others. Not more than a quarter to a third of the scholars will find permanent independent employment in after-life.

Shrubsall and Williams (*L.C.C. M.O.*, 1922. 45), in analysing the cases of defective delinquents, attempted a classification by their employment records, and the following has been abstracted from their table—

TABLE 63.

Defective Delinquents.	Unemployable.	Occasional Employ.	Regular Work.	Just Left School.	Total.
Males	73	97	48	16	234
Females	22	34	23	2	81
Totals	95	131	71	18	315

Allowing for wastage from migration and death, two-thirds of the mental defectives should have constant custodial treatment from school-days on, not merely as a matter of State economy, but so that by direction and regulation of their activities they may make the fullest and happiest use of their lives, the common aim of all. As concerns the community they are nothing but a burden which is constantly increasing, so that it has now become a public duty to prevent these people coming into existence, so far as that is possible. This is a purely scientific question, and will only benefit coming generations, but it is a duty with which no idle speculative sentiments or vain religious scruples should be permitted to interfere, and for their own happiness, as well as the benefit of others, they should all be sterilized.

CHAPTER XXII

THE PRE-SCHOOL CHILD

The Pre-school Child.—From birth till it has attained its human mode of upright progression a child is parasitic on its mother. Treatment is for both and embraced in "maternity and child welfare." So far as the community is concerned this is a single service within the field of Public Health, which by means of Child Welfare Centres, and as at Bristol by co-ordination with school clinics, continues care till the age of 5. These arrangements will be seen later to fail in satisfying the greatest needs of the pre-school child, still strangely overlooked and neglected by the Board of Education.

This period is also covered for special cases where the mother has to work, or for other reasons cannot give the child sufficient care, by crèches and day nurseries.

Day nurseries are not educational arrangements, and although they are recognized for children up to the age of three years, they may be expected gradually to disappear. Only in one regard is there serious and obvious default at this stage, and that is in neglect to make suitable provision for early care, and prevention of crippling, due to poliomyelitis, although for those where damage has been done, and crippling established, orthopædic schemes are now developing.

Once the child sets out by itself on life's highway, even if it only goes through the house door, to run back to its mother at the first strange happening, its development has reached a stage which makes it an active, independent member of the community. Using the expressive word picked by Lady Leslie Mackenzie from the Scottish vernacular, it has become a toddler.

Toddlers' playgrounds emerged in Edinburgh. At home the toddler is a handicap to a nursing mother with household duties and cooking of a midday dinner. The Edinburgh experiment attempts to relieve this by taking care of the toddler, and is found also to have a beneficent reflex effect on many homes.

Admission to the playground is conditional. First, there must be a baby at home needing nursing; second, the mother must undertake to prepare the school children neatly and cleanly for school, and to prepare the toddler for transference to the play-

ground ; third, she must maintain a reasonable standard of tidiness at home.

Children are taken till the mother has had time to prepare dinner, when they return home. Equipment is simple—sand, rocking-horses, shelter for bad weather, and a careful attendant. Education is not excluded from the toddlers' playground. The primary purpose is to establish the children in vigorous health.

Care of children under 5 years of age in Scotland comes under the Public Health Department, and some aspects of it do this in England. In the case of the toddler's playground alone it would be a matter of indifference, so long as they were definitely committed to one authority to prevent neglect. There are some administrative reasons for treating them as educational and using school clinics and school machinery. They should not remain islets in no man's land. The serious condition has become well established that the Board of Education and Educational Authorities neglect children of this age, whilst Sanitary Authorities merely permit them to exist nominally under the ægis of child welfare clinics. One or other authority should have the whole responsibility for children of the age 2 to 5 years placed upon it for health care, nutrition, play, and educational development.

Meanwhile, in towns, scheduling side-streets against wheeled traffic for some hours daily would effect considerable provision for those at present condemned to the gutter. The choice of provision for the majority of town children aged 2 to 5 lies between the nursery school and the education of the gutter.

Education is not reading or writing, nor is it mere acquirement or teaching of information. Education is all that affords or necessitates development of the potentialities of personality. It should be a universal service, caring for every child, so that none can escape and none be neglected.

Education is the public health, physical and mental, of the developing individual, and must be either included in Public Health or separated from it. If separated, a dividing line must come somewhere.

What Authority is to be Responsible ?—The dividing line between education and other public responsibilities is one proposed by the writer when the subject was first explored. "The whole State provision for aiding the growth and development of the child from the time it ceases to be entirely dependent upon its parents until it attains puberty, constitutes formal education (*L.C.C. M.O. Ed.*, 1908) ; that is, from 2 till 16 years of age is the period for control wholly by the Education Authority.

Provision for the pre-school child is often dismissed by superficial educationalists in the phrase that "the best place for the child is in the home." This may have been true a couple of generations ago.

Then the older children were not absent at school, and industrialism had not invaded homes to take many mothers away; then the home was the centre of family activity. Land was freer, plenty of playground was at hand, and the dangers of traffic small. All this has vanished. There are few children in England to-day from 2 to 5 years old, of whom it is even an approximation to truth to say that the best place for them is in the home. Home is a centre, and a basis to which a child should be able to refer and fix its mental activities, but it is not a roomy place to run about in.

The child needs daily sleep, it needs play, it needs happy companionship. Margaret McMillan has shewn how activities of the playground, association with its mental equals in conditions of safety, afternoon rest, all conditions rarely to be found in an average English home, can be cheaply and advantageously got in the nursery school. She first demonstrated that in fresh air with plenty of light, plenty of space to run about in, the child can have opportunities co-operatively provided, otherwise accessible only to the well off. No one who visits the Rachel McMillan Nursery Schools can fail to realize their possibilities.

Nursery Schools.—The child of 2 is permitted to attend a nursery school if there is one to attend, but at present there is one place for every 500 children of pre-school age.

The Education Act, 1921, Section 21, reads: "The powers of a local education authority for elementary education shall include the power to make arrangements for

"(*a*) Supplying or aiding the supply of nursery schools (which expression shall include nursery classes) for children over 2 and under 5 years of age, or such later age as may be approved by the Board of Education, whose attendance at such a school is necessary or desirable for their healthy physical or mental development; and

"(*b*) Attending to the health, nourishment, and physical welfare of children attending nursery schools."

Regulations for special services in Education (No. 19. 1925) apply to nursery schools, which must be open at least 200 days in the year, with the usual proviso regarding closure on medical authority. The opening at least on 200 days, of course, does not prevent opening on 365 days in the year, if desired.

Chapter VI. 24 (3) states that "no child may be admitted to a special school, under 2 years of age"; presumably those needing it will be admitted at this age, which in the case of the congenitally deaf is the optimum age for instruction in lip-reading, and all such children should then be placed under special care for this purpose.

When Education Authorities use their powers, the Board have wisely indicated that the nursery school is to be more than a place for minding children. It must provide for definite training bodily,

mental and social. They suggest hours 8.30 a.m. to about 5 p.m., and stipulate provision for meals, and also for rest and sleep. Ample provision for open air-life must be furnished and opportunities for free movement. In no case should the number of children exceed 100. There seems no virtue in this 100 limit, and earlier hours are wanted to relieve mothers, and to attend well to the children.

This memorandum sets forth an excellent ideal, although there is considerable danger that definite training of a mental kind may degenerate into an unwholesome stimulation by teaching. Nature will train the nervous system itself if opportunity is given. The training by imitation and deed will be better than any attempts at formal education.

The key to those early years is to provide a suitable environment, with plenty of simple sights and sounds to sink into the fabric of the child's brain, and help to form the substratum of experience on which its character for sociability, helpfulness and happy service at this stage will develop.

Infant departments for many years have had baby rooms and baby classes, and it was formerly permissible to admit children from the age of 3 years, except in places where authorities kept such children out of school. These baby classes, good as they are, have a bias of preparation for school-work which should be removed from the nursery school.

Powers and capacities of the pre-school child are habitually overestimated by parents and others. A two-year-old ought to be able to get about easily by itself. It should have a vocabulary of words in common use at home, although it has not yet attained full use of a sentence, nor does it use pronouns, till well on in the third year, when "me" comes in, followed later by "I."

Dentition is not yet completed. There should be sixteen teeth by the second birthday, and all twenty by $2\frac{1}{2}$ years of age. The number of teeth should be recorded on admission, as a guide to future development. If the fontanelles are not completely closed, as they ought to be at 18 months, serious retardation is to be suspected. Heights and weights of boys and girls are given for each quarter year on page 20. Seven per cent. either way for weights, and 3 per cent. for height, may be taken as normal variation at these ages.

The chief part of the child's life now is nutrition and growth. This growth has to be carefully watched; every child in a nursery school should have height and weight charted at a regular hour and date in each month (Fig. 159).

At the beginning of nursery school-days, the concentration must be on conditions favourable for nutrition. These are feeding, oxidation of tissues, active circulation of blood and lymph, and sleep. Its general appearance in respect to condition of the tissue

textures, hair and skin, especially colour, as shewing circulatory efficiency, and fatness should always be followed. The child requires protein, not in the form of meats, but as milk. At the age of 2 to 3 it really needs about a quart of milk a day and carbohydrates in the form of various cereals. Green vegetables should come in the diet, or small amounts of such protective materials as orange juice. Feeding is an essential provision in all nursery schools; even if children go home to a midday meal, there should be a mid-morning milk and biscuit, and some more following afternoon sleep.

Development of the teeth needs good crusty material, some hard biscuits and hard nuts and fruits or raw carrot, as masticating materials. Heat removal is necessary by plenty of fresh air if possible, but chilling of the skin has to be avoided. All the sunshine outside, that it can get in England, will scarcely harm a child, except that care may be wanted in the hottest summer days. The whole idea of the nursery school is an open-air school all the time, with feeding and rest.

After the age of 3, food should gradually approximate to adult mixed diet, but still during development every child requires at least a pint of milk a day. Preserved and conserved materials of diet are so devitalized nowadays that special regard has to be paid to this during growth.

The best methods of chest expansion are violent games the children indulge in themselves. The reserves of children are almost non-existent. They fatigue easily and become inattentive. No child before school-days is fit to go through twelve hours without sleep. Before the age of 4, there ought to be one and a half hours of sleep interpolated somewhere between 11.30 a.m. and 3.30 p.m.; after this age, an hour is the minimum, but longer is an advantage. This sleep should be regarded as a necessity for every child up to 7 years of age.

Little stretchers for sleeping similar to those used in open-air schools are used, but all kinds of arrangements have been tried by teachers. Tables turned upside down and towels with loops round slung on the legs have been found in use by ingenious teachers who appreciate the need of sleep for infants.

Muscular activity soon becomes a passion with the child. It wants to creep and climb and slide and jump. All this should be provided. Some ball games should be played. The exercises of children need not involve any drills, or movements to command. They should be told to do simple things and left to do them.

Special attention should be given to the floor surface. The best arrangement would be the Derbyshire plan of heating through the floor to keep the surface to 75° or 80° F. The writer well remembers his last visit to an infant school in London, on a cold winter day, with wet patches here and there on the floors, and

FIG. 84.—THE JUNGLEGYM FOR THE NURSERY SCHOOL.

children lying about asleep on the damp boards, in all kinds of attitudes.

There is an enormous amount of useful education to be given at this age, which will have far-reaching effects on the physical efficiency of later life. The kinæsthetic sense, in which muscular movements play so great a part, underlies most of the intellectual memories which are destined to round off the later performances of life activities. It may be possible to call out the child's spontaneous adjustments without stating in words all that is to be done.

Walking over stepping-stones involves many gradations, gradually improving. Bricks laid at intervals as stepping-stones, transversely or parallel, to the direction the child has to go, involve adjustments which no teacher could inculcate by other means. The child at first would look where its feet had to go, later it would keep its eyes level. The skipping-rope, too, will be a valuable if more restricted exercise. The rapid fatiguability of neurones in their most plastic period of growth gives an indication that no effort should be long continued, and frequent repetition at considerable intervals will be the keynote of a young child's work.

A continuous effort of a couple of minutes is excessive. The arm held out sideways and straight, with the hand level with the shoulder, although this mainly involves the larger muscles, soon shews by its sinking how easily fatigue comes on.

Merely sitting still in desks calls for control and adjustments, which make it so trying to young children that no good teacher would inflict it for seconds rather than minutes, on a class of young children.

Years ago the sitting in class with arms crossed behind the back was shewn in Germany to be a severe physical task often causing congestion of the kidney, so that after a few minutes many children shewed albumen in the urine.

The type of ordinary school discipline which can be borne by children ten years older, is an abomination in pre-school days.

Nutrition, rest and exercise is the whole purpose of life at this time, and any other kind of educative attempts beyond arranging and directing these into good habits may be not merely inefficient, but misguided and harmful.

Walking the plank, jumping off a box, climbing up a gate, sliding down a slope, can all be used to the greatest advantage educationally, and graduated in difficulties. The junglegym used in American nursery schools is an admirable play occupation. Interpolating a good run, between a climb up and a slide down, adds to ventilating effect on the lungs. These activities also stimulate lymphatic circulation, and clear the tissues for improved metabolism.

Spray baths are desirable as part of school routine. Fear of

physical obstacles or conditions requires elimination from the earliest. Swimming can be taught by imitation from about 4 years of age.

Something to attain, an object to be gained, a step to advance—all these have enormous advantages, in the combinations and reflexes brought about being spontaneously educed. The less direct interference comes in, the better for the child, who has to do its own subconscious education.

There need be little work at tables or desks below 4 years of age. Although the more precocious begin to learn them spontaneously, letters and numbers should not be mentioned as part of the school-work. The mental reactions of the pre-school child have been examined by Baldwin and Stecher (*The Psychology of the Pre-school Child*, Appleton), but postponement of all fine work, whether with beads or form boards, is advisable till the infant school is reached. Neither eye muscles nor finger movements can be long kept at work without strain.

In a school such as this, whoever is in charge must have a knowledge of and regard for physical development, rare among ordinary teachers. The school nurse will be important. The administrative head should be a trained teacher, otherwise workers will best be young, under 20 years of age. No one over this age should be employed unless a certificated nurse or teacher. These children cannot be managed in big classes ; six or eight will make a suitable group. The object is to permit unhindered development as a result of experience and to exclude direct teaching.

Medical inspection is required as soon after admission as possible, to determine the status of the child. After that, notes should be made monthly of height and weight, and quarterly by the nurse of general condition, and by the doctor at not greater intervals than six months.

There are few available records of conditions to be found, beyond deductions drawn from routine school inspection of entrants at five.

In Warrington (1923) entrants who had attended welfare centres only presented 17·3 per cent. with defect, whilst those who had not attended such centres presented 26·9 per cent. defective.

Dr. J. Sobel made records of 2000 pre-school cases in New York : 1 per cent. were mentally defective, 2 with aural, 3 with tubercular disease, 4 with visual defect, and 7 per cent. with various orthopædic conditions. One-fifth required dental treatment, and a quarter for nasal obstruction, a quarter enlarged tonsils and adenoids, and over a quarter with malnutrition.

Squinting will be the most obvious defect of the eyes, and it is only at these ages that any treatment is likely to be effective.

Tubercular disease of bones, joints or spine has to be watched for and early treated. Any defect in posture or gait will call attention

to the possibility, as it is at this age that most crippling defects originate (Fig. 43).

This period is one in which dental hygienists might be active, as healthy mouths now aid the eruption of good teeth later. The regular use of lime water as a mouth wash after meals is advisable.

In the examination of 3125 pre-school children at Gary, Ind. (U.S.A. Children's Bureau, No. 111. 1922), the most conspicuous single defect in the entire pre-school group was carious teeth. At ages 2–3 there were 21·5 per cent., at 3–4 43 per cent., and at 4–5 two-thirds, or 66·2 per cent., had caries, and 95 per cent. had had no dental care. Gum abscesses were in 3·2 per cent., and 11 per cent. shewed malocclusion.

Signs of rickets have to be looked for in entrants as cod-liver oil will be required, or they may even need treatment by light. Discharging ears should be assiduously cleansed. Many of them recover without treatment, but attention in school may obviate deafness later.

These youngsters are so imitative and so receptive and suggestible that no fault should be mentioned. In the development of speech the least anxiety as to correct speech will easily make a nervous child begin with stammering. There is a physiological stammer noticed in beginning of speaking sentences. Speech should be corrected indirectly; the child who has difficulties can be taught to sing or say a little rhyme or verse by ear to correct his articulation. Much articulatory default in complicated consonants will be noticeable till after the infant stage is passed. Allusions or definite references to faults may result in their fixation.

The great opportunity of pre-school age is chance of noting early deviations, not only physical but also mental; any unusual or excessive behaviour needs observation. Instinctive and emotional behaviour, out of normal control, may require treatment. Where such a case is detected, the home also must be investigated by the nurse. There may be an emotional mother or some other cause, but possibly a habit clinic to which the doctor will probably refer the child, will straighten out all these questions, and obtain results of more permanent value than could be got in later life, adding to the child's happiness and usefulness.

The young child coming into school is egocentric. Things only affect himself; he is either defensively mute, or often wants only to talk about himself. One cannot call it selfishness; that is an intellectual condition of later life. At this stage action is almost emotional reflex to sensations aroused by surroundings. The child does not yet realize or take into account feelings of others. The single child in the family, now becoming too prevalent, always suffers in this way, and defect may be very persistent. Often there

is insufficient toning down and adjustment to interests of the rest of the child community, and much suffering to the lonely mind.

A child can learn many useful habits. Soon after 2 years, by $2\frac{1}{2}$, it should be able to feed itself, use a spoon, and wash its own hands ; by 3 years to $3\frac{1}{2}$ years it should bathe itself and begin to brush its teeth and put on its shoes, fastening up buttons about $3\frac{1}{2}$; and by 4 years it should be taking a part in management of meals, even washing a dish, or tidying up. Personal cleanliness must be a feature of school and habits of neatness in putting away toys, rearranging chairs, and other adjustments. Generally speaking, the child on admission to the lowest infant class, can walk, but some cannot even do that properly ; some can run, but many fall in the attempt ; few dare jump off a chair ; many have dirty habits.

The youngster sees and hears, so far as its eyes and ears are concerned, better than at any time in subsequent life, but it has not the intellectual development or capacity to understand most things seen or heard. The extraordinary imitativeness of young children is a comparatively lowly function often present in animals, and markedly in many feeble folk, particularly in the group called mongols.

The pre-school child and infant may be allowed chalks to scribble with as soon as they can begin drawing. Drawings are early racial forms of expression. After spoken language, drawings should be the only attempts at educational expression in pre-school ages. There should be no letters learned there. Detail is wasted on children, although they may pick up much subconsciously. The difficulty of learning letters or words is simply from the brain centres not yet being organized ; even if they learn, they forget almost as quickly.

Determine as early as possible whether a child is right-handed or not. Various little tests may be used : which hand is used to hold the chalk in drawing ? Or he may be asked to drop marbles one by one through a small hole into a box, and the hand used observed. Left-handers should be practised with right-hand work quite early. True left-handers are as rare as word-blind children.

These early ages are also ages of acquiring kinæsthetic muscle sense. Stringing large and varied shapes of beads, using simple jig-saw games, using building bricks, perhaps even plasticine or plastic wire, and stick laying can come in for work on wet days. Blowing soap bubbles is quite a good game for the three-year-old —younger they fail, older they lose interest in it.

Personal cleanliness of clothes and hair and detection of vermin will be regulated, but a particular activity of the nursery school must be instant detection of infectious disease. Parents should understand that no child with a sore throat, a rash, or who has vomited or had headache, should come to school until they are

accompanied, and this is notified, and the child seen by nurse or teacher before mixing with others. It would perhaps be well to note children in whose homes there had been measles within three months of the child's birth, as in that case the infant is probably immune.

A description of a day at the Merrill Palmer School in Detroit will give a good general idea of the scope of activities in a nursery school. This school is an experimental and observational school, in what is perhaps the most advanced school hygiene centre at the present time, and its pupils are socially considerably above the average.

The children arrive about nine o'clock in the morning. They are first inspected by the nurse, and any who shew signs of infection which make it undesirable for them to mix with other children are at once isolated and sent home. The others choose their work. If a child needs help and asks, he gets it. If he can carry on without help, he is encouraged to do so. Effort is made to see that each child completes what he starts on, before going to anything else. He must put it all away before beginning anything fresh.

After an hour of this individual work children are gathered in a circle for the "news" of the day—to hear a story, play a game, or dramatize a song for a quarter of an hour. Then a snack of a little fruit and a drink of water, and they go out to play for an hour. They again choose their occupations, play in the sand, or games, or swing or climb as they like. Coming in from play, they wash hands and faces, and go into school for a music lesson, which is exceedingly popular. None need join this, but nearly all do. At the end of the music they lie down for relaxation. Some set table for lunch, and when all is ready the others come and take their places. All serving and changing of plates is done by children themselves. Then a sleep of two hours is followed by a glass of milk, after which they go out again.

It was thought at first that school routine might be too stimulating, or too fatiguing for some, but they all gained not only mentally and physically, but also in social reaction.

The whole idea of education in the nursery school is general preparation of a well-equipped machine for later life, not of a pupil of the big school and its three R's. There should never be doubt or indecision about the next thing to be done ; no hesitation, fear, or timidity about actions.

Such is the work of the nursery school as the writer has pictured it for many years. Nowadays, all these children should be immune to diphtheria. The next twenty years will unveil much knowledge of use at these ages, which may make them the chief battle-ground of preventive medicine. The field as yet is almost untouched.

Except whooping-cough, there is none of the common zymotics whose complete control cannot be envisaged. They have ceased to be a fear here, if known means of prevention are used.

As regards the main purpose of the nursery school at present, it should be directed towards nutritional and muscular activities.

Its aim—and there cannot be a higher one—is to turn out a fat, smiling, happy child at 5 years of age, who can fearlessly walk along an inch board or jump off a chair without hesitation. He will be 100 cm. or more high, and weigh nearly 18 kilos—say, roughly, weigh 40 lb. and stand 40 in.

Lastly, he will look on everyone as his friend, and want to lend a hand in every enterprise.

Inspections and examinations of nursery schools will be necessary, but there is danger that they may restrict the freedom of aim, and hinder the purposes as aiding development.

Something like a score card needs constructing, so that opportunities afforded in the way of diet, cleanliness and rest, and the provision for various kinds of exercises, can be assessed.

The work accomplished must not be set out in spurious educational tricks, but in the freedom of the children from hindrances to full development, whether due to disease or want of opportunities; their growth as set out by indices from weights and heights, and their physical and mental condition as shewn by motor reactions in attitudes, postures, expression and manner, at rest or in movement.

CHAPTER XXIII

VISION

School hygiene as a scientific study almost began with ophthalmic researches on the use of the eye.

As eye and ear are the chief gateways of learning, hindrances or defects here are of prime importance. The eye may be regarded as a specialized brain centre sensitive to light rays. In the lowest types of seeing animals it merely consists of a few pigmented cells on nervous structures towards the anterior of the body.

In more highly developed forms there is in the embryo a stage whilst the brain is forming, when two vesicles are pushed out from each side towards the skin. They become involuted to form a

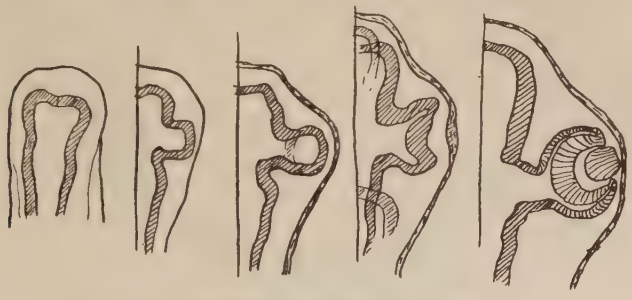


Fig. 85.—SCHEME OF DEVELOPING EYE.

cup-like mass on a narrow stalk. Ultimately, by pushing in of other tissues from below and across the opening of the cup, this forms a hollow rounded mass which gradually develops to the nearly spherical eyeball on the optic stalk. Down this stalk run the nerves and blood-vessels connected with the nervous elements.

The folded-in part of the cup goes to form the retina, or nervous sheet, which is sensitive to light, and which is really the important outgrowth of brain containing nerve endings, in rods and cones, which are receptors for light.

The other structures of the eyeball are accessories for retinal protection or efficient working. The growth of eye and brain go on at nearly the same rate, increasing about three times between birth and maturity ; growth in weight of the rest of the body being over twenty times the birth weight.

Congenital defects occasionally met in children are due to incomplete growth of these structures, leaving gaps, as in coloboma of iris, or coloboma of choroid, or leaving shreds or masses behind as in tags or threads across the pupil or remains of structures behind the lens. Details of these must be sought in ophthalmic text-books.

General Structure.—Some points in ophthalmic anatomy have to be recalled in connection with educational hygiene. On examining an eyeball, about one-sixth of its area in front is found to be formed by the slightly more curved surface of the cornea. In a normal

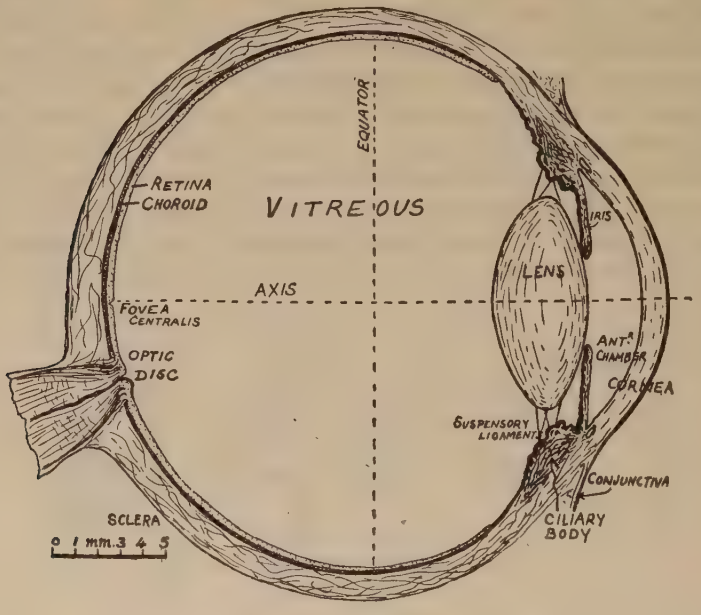


FIG. 86.

eye this is clear and transparent, but tough and surprisingly hard. It cuts like a finger-nail softened in hot water.

From near the posterior pole of the eye the optic nerve with retinal vessels passes down and inwards to the optic commissure at the base of the brain. A horizontal section of the globe through the optic nerve will shew main structures.

The tough white fibrous sclerotic coat preserves the form of the globe; inside this is a vascular layer known as the choroid coat, and on its inner surface a densely pigmented layer of black hexagonal cells. Within the dark chamber thus formed is the thin transparent retina, a layer about 0·06 mm. in thickness (Fig. 92). It is made up of radially disposed nervous receptors, closely packed, light sensitive rods and cones. These are connected in front with layers of nerve cells forming nuclear and granular layers of the retina.

The rods are about 0·0018 mm., and cones about 0·004 mm. in thickness.

Exactly at the posterior pole of the eye, over an area of about a millimetre radius, the nervous layers thin out and then vanish, except the rod and cone layer, which, in the centre at a small spot about a quarter of a millimetre across, called fovea centralis, consists only of cones.

Edridge Green supposes cones to be nerve terminals or light receptors, and rods to manufacture visual purple which sensitizes them. Parson's idea of rods as protopathic and cones as epicritic in function is more satisfactory (Bowman Lecture, 1925).

From its slightly yellowish appearance, the small spot at the fovea, now termed the macula, was originally called macula lutea. It is the most sensitive part of the retina. Here the sharpest image is formed on the rods and cones as there are no nervous layers to scatter the rays in passing. The optic axis of the eye, the line approximately passing through the centre of cornea and lens, should also pass through the macula. About 3 mm. from the macula towards the nasal side, where nerve fibres converge to pass down the optic nerve, nuclear and rod and cone layers disappear. This is the nerve head, and can be seen by retinoscopy on looking into the properly illuminated eye as a whitish disc with retinal vessels radiating from it.

The nerve fibrils, being non-medullated in the retina, do not shew. Occasionally some fibres are medullated and appear as whitish threads or radially striped fan-shaped masses. In some animals this is a normal condition and accounts for reflected shine in a cat's eye when it faces the light from behind the observer.

Over the area of the disc where rods and cones are absent there is no sensitiveness to light; it is known as the "blind spot." The disc, about one and a half to two millimetres across, is the chief landmark on examining the interior of the eye by retinoscopy. Thus magnified, it appears as a whitish, rounded spot, "about the size of a sixpence," and the macula is seen like the impress of a pin's head, about two disc breadths from its outer edge. The distance between the disc and macula is said to be nearly as great at birth as later.

By the process of seeing, a picture of the external world in the "Field of Vision" is formed on the retina by light passing through a system of curved surfaces. These are surfaces of cornea and fluid media, and lens structure, which last separates contents of the eyeball into an anterior chamber, and a posterior chamber filled with an almost fluid gelatinous material named the vitreous body, which is in contact with the retina and posterior surface of the lens capsule.

The lens is a laminated, very transparent ovoid, suspended in

its capsule in the front part of the globe across the opening behind the cornea. The anterior chamber, filled by aqueous humour, is the space between front of the lens and cornea. Round the interior edge of the opening in the globe covered by cornea is a thick and radially rugose collar of tissues made up by continuation forwards of part of the sclerotic and choroid coats. This is the ciliary body.

From these tissues continued forward into the anterior chamber, a little in front of the lens, is formed a thin annular membrane, the iris. The variable circular opening in this is the pupil, which by its widening or narrowing regulates the admission of light to the eye.

Although Helmholtz is credited with saying that if an optical instrument maker had sent him such an instrument he would have

FIG. 87.—THE FUNDUS OCULI.

The fundus oculi as seen by the ophthalmoscope; the disc with the narrow arteries and thicker veins. Towards the right the macula, usually of a darker colour, which it has been attempted to represent by stippling.

returned it as too imperfect, the process of evolution has furnished us with an extraordinarily fine instrument, better than any produced until within the last year or two. It consists essentially of two parts: (i) the finder, for general observation of coarse objects and movements over a wide safety field, in the peripheral retina; (ii) the high power accurate macula of extraordinarily great sensitiveness over a small area. If this area is considered as the image, then with the pupil at its widest, say 7·5 mm., and the focal distance as from the nodal point to retina 15 mm., the ordinary emmetropic eye is an instrument with a possibility of working at $\frac{f}{2}$, and ordinarily working about $\frac{f}{4}$; a very satisfactory performance optically.

The lens lies behind the pupillary plane and is slung by numerous fine radial fibres stretching from the ciliary processes to where the capsule passes over the edge of the lens.

The measurements of the normal adult eye at rest, to which by 8 years of age the eye of a child approximates within 3 or 4 per cent., may be stated—

Radius of curvature of cornea, 7·83 mm.
Radius of curvature of anterior surface of lens, 10 mm.
Radius of curvature of posterior surface of lens, 6 mm.
Distance of summit of cornea to anterior of lens, 3·6 mm.
Thickness of lens, 3·6 mm.
Distance from summit of cornea to retina, 24·3 mm.

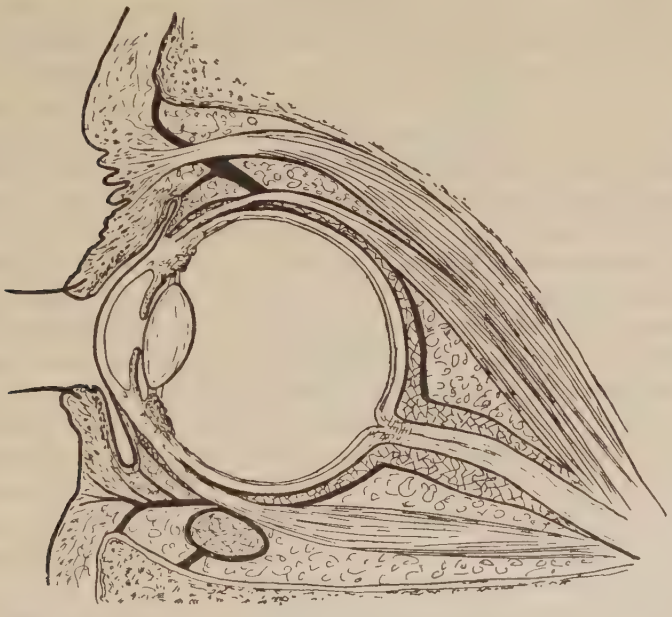


FIG. 88.—SECTION TO SHEW RELATIONSHIP OF EYE AND ORBITAL STRUCTURES.

For purposes of calculation, these various structures can be replaced by a theoretical *Schematic eye*, the nodal point of which lies just about the point where the axis cuts the posterior surface of the lens—that is, about 15 mm. in front of the retina, and the axis of each pencil of rays will pass through this point.

The eyes are placed symmetrically in each orbit, the thick, bony, upper edge of which protects them. Each eye can be moved freely about its centre by a set of six small muscles which are attached to the globe. Of the two lateral, an internal rectus turns

the centre of cornea towards the nose; the external rectus acts in opposite direction. Of the two vertical, superior rectus turns centre of cornea up, and inferior rectus draws it downwards and inwards. There are two oblique muscles; superior oblique or pulley muscle tends to rotate cornea down and outward, inferior oblique acts in the opposite way. The muscles all act together, steadying the eyeball, and act practically instantaneously in various adjustments, so that their actions are really rather more complicated than simple movements, as stated above. The inferior oblique and superior rectus, for instance, acting together, turn the eye directly upwards. From a study of after images it is evident that the eye is never rotated about its antero-posterior axis.

The globe and these muscles are packed around with loose connective tissue, the interstices containing masses of fat. In front the eyelids protect the globe; towards their edges they have a dense fibrous layer, the tarsus, which gives them solidity. The upper lid is largest, and covers most of the cornea when the eyes are closed or in winking. It is raised by a muscle, the levator superioris, which is sometimes very feeble or undeveloped, so that the upper lid is only partly raised in congenital ptosis. Patients with ptosis, which sometimes runs in a family, have to throw back their head to some extent to see the person they talk to.

The cornea and visible part of the eye is covered by a delicate conjunctiva which is reflected on the inner surface of the eyelids. The potential spaces between the lids and globe form the upper and lower conjunctival sacs. The lids unite at the outer canthus. Near the inner canthus there is a small angle on each eyelid, where the openings to the lachrymal duct through which the moistening secretion, in excess forming tears, drain into the nasal passages. Sometimes a small fold of skin runs from the upper lid round the internal canthus to the skin of the cheek or nose. It is known as an epicanthic fold. The condition is shortly termed epicanthus, and is common in the so-called "mongols."

The lachrymal gland is tucked away in the upper and outer angle of the orbit. Its edge can sometimes be seen on turning back the upper lid. The upper lid is best everted, if the lower lid is first pushed up under it.

The lid edges have the eyelashes growing outwards and protect the globe from insects or foreign bodies. On the margin of the lid within the row of eyelashes, the Meibomian glands open, a row of small sebaceous glands whose oily secretion lubricates and softens the lid margins.

External Diseases of the Eye.—It is impossible here to deal with any but the commonest eye conditions interfering with education. Catarrhal infections and other micro-organisms affect the conjunctiva, causing conjunctivitis in various forms. The conjunctival

sac is warm and moist, forming an ideal incubating chamber for growth of micro-organisms, and many varieties maintain a futile struggle for existence. They are washed away or actually destroyed in tear secretions. But with any diminution in immunity or power of resistance in the tissues, there may come liability to varieties of catarrhal inflammation.

Ophthalmia Neonatorum.—Usually it is the common skin cocci of low pathogenic powers which maintain a sub-acute inflammation.

FIG. 89.—THE CONJUNCTIVA AND LIDS.

1 Cornea, 2 iris, 3 ciliary body, 4 lens, 5 upper and 6 lower conjunctival sac, 7 opening of a Meibomian duct on edge of lid, 8 tendon of levator muscle, 9 orbital fascia, 10 sclerotic, 11 tendon of inferior rectus, 12 on a Meibomian gland in upper lid, 13 frontal bone.

The most destructive form of conjunctivitis among nurslings is from gonococci, the main cause of ophthalmia neonatorum. A violent conjunctivitis may appear a few hours after birth, due to infection by maternal secretions, still infective from past gonorrhœa. It can be prevented or aborted by the use of Crede's method, a 2 per cent. solution of silver nitrate dropped from a glass rod, after careful washing out of every corner of the conjunctival sacs. This is necessary for any child shewing the slightest sign of conjunctivitis in the first few days of life.

In Crede's clinic at Leipzig the incidence was 10·8 per cent.

till he introduced the silver nitrate method, when it fell to about one-hundredth of what it was, and remained between 0·1 and 0·2 per cent. Most cases should at once be taken into hospital care; four or five hours' delay may mean blindness.

Sanitary care will work wonders. Dr. Josephine Baker, the Chief of the Child Hygiene Department in New York, describes how, "beginning ten years ago with no method of finding out whether there were cases of blindness, we had literally thousands of cases of ophthalmia, and hundreds of cases of blindness." Last year (1921) 35 cases and only 1 blinded: "Nothing that I know of has changed in regard to the practice of doctors, but a very great deal has changed in regard to the practice of midwives."

The resulting corneal opacities seen in later life may vary from merest haze or nebula to a leucoma or dense fibrosis of cornea, and blindness. Sometimes the eyeball is destroyed through rupture of the cornea. Rarely are both eyes so seriously affected that the child is permanently blinded. Occasionally iridectomy may be tried, but as a rule effects little improvement. Sometimes, through blocking of the lymphatic drainage of the eye, from the pressure of inflammatory effusion and swelling of the iris, leaving a permanent obstruction, the whole globe gradually distends. The cornea thins and in later life the eye may have to be removed. From its large, prominent appearance it has been termed buphthalmos or ox-eye.

In London, since the War, roughly about 1 per cent. contract what is called ophthalmia neonatorum—that is, about 800 cases annually—and about 1 in 2000 is visually damaged.

In United States Blind Schools in 1920–21, out of about 4000 blind pupils, 22 per cent. were due to ophthalmia neonatorum, but of the new admissions only 12·6 per cent. (*The Newsletter*, February 1925). The proportions among the new admissions fell steadily from 26·6 in 1907–8 to 13·5 in 1920–1, and 12·7 in 1925.

The City of Buffalo, with nearly a million inhabitants, has now had no case of blindness or scars from ophthalmia neonatorum for nine years (1925).

Blepharitis.—Other varieties of conjunctivitis are rarely as serious. Many ill-nourished children, especially those frequently called strumous, are subject to various slight catarrhal conditions with some increased redness and secretion. A cold in the eye is due to dust or material of slight infective power.

Monocular conjunctivitis may be due to dacryocystitis, to a foreign body or some such local cause, which should be excluded, before treatment as a bacterial infection. Lachrymation and sensitiveness to light are early symptoms of conjunctivitis. In many cases repetition leads to a slight degree of chronic inflammation of lid margins. The chief agents seem to be the common

skin staphylococci. Secretion drying, forms small accumulations of scales, and with poorly nourished children of low powers of resistance, chronic inflammation leads to redness and thickening of the lid margins, and later perhaps to worse degrees and loss of eyelashes.

This chronic conjunctivitis and blepharitis is often seen in hypermetropic children, and is sometimes relieved by glasses which diminish any straining efforts, and seem to protect the eyes from dust and dirt. The condition has generally lasted for months when first seen by the doctor, and then may be ascribed to a recent attack of some disease like measles. It is a concomitant of ill-nutrition, possibly of unsuitable food and of unhygienic conditions of squalid housing.

Bishop Harman called attention to relation of visible lymph follicles and prevalence of nits in the hair at different ages. Hay, in the Medical Report for Sheffield Schools in 1913, distributed cases seen in a year as follows—

TABLE 64.

SHEFFIELD, 1913.

	Numbers Seen.	Conjunctivitis.		Blepharitis.	
		Cases.	Per 10,000.	Cases.	Per 10,000.
Better class districts ..	10,290	13	13	6	6
Average schools	41,460	113	27	33	8
Poor districts	29,428	252	86	77	26

It is relieved by cod-liver oil, fresh food and milk, and above all, by a change of living conditions to fresh air, plenty of light, and preferably the seaside. It often accompanies unhealthy or slight septic throat and nose conditions, and is then prone to relapse or resist improvement till adenoids, tonsils or nasal obstructions have been remedied.

When the writer first saw it in London, teachers called it " blight " and were extremely afraid of it as contagious, which is not the case.

Acute Infectious Conjunctivitis.—As a sample of a violent outburst, in an outbreak in Charlottenburg, in one class in the middle of March, 23 of a class of 50 girls had bad eyes. Next day 70 children were affected. The class where it first appeared was closed on March 17th, and the department on the 21st. The following day 170 boys were affected and their department was closed a couple of days later. The disinfection of the building was allowed 20 days. On May 1st about 2000 children were examined by official surgeons,

and only four with bad eyes were noted (Feilchenfeld, *Zeit. f. S.*, 1903. 677).

Outbreaks in elementary schools are rarely violent. The writer has never seen one of the type described above. In a residential or an industrial school there may be many cases spread over weeks, but they are generally mild.

The eyes feel gritty and hot. They are pink and moist in appearance over the ocular conjunctiva. They are sensitive to light, and occasionally there may be acute blepharospasm. In a few hours some have acute inflammation with abundant muco-purulent discharge. It slowly subsides, but the child is infectious for a week or two. As a warning, on one occasion in an outbreak, the school

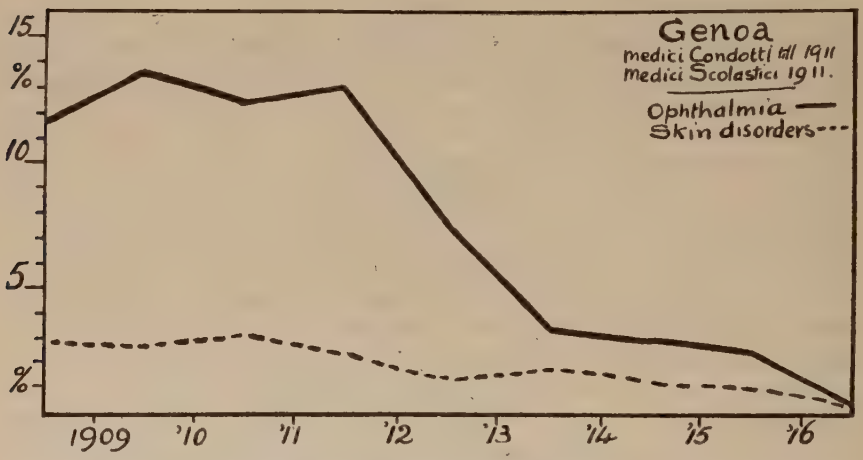


FIG. 90.—IMPROVEMENT RESULTING FROM INTRODUCTION OF SCHOOL DOCTORS IN GENOA.

keeper was said to have been affected for a couple of days; he presented the typical picture, but one eye, being much worse, was carefully inspected, when removal of a flinty granule caused rapid subsidence.

School treatment is to send each affected scholar home at once with instructions that the child is infectious, and must not return to school until it is well. Meanwhile, it should use only its own towels. Withdrawal of all towels and washing facilities at school is essential; it generally ends the trouble in a short time for the day school.

In residential schools the best course is to adopt separate classes for those affected, and frequent eye douching with sublimate solution of the strength of one part in two thousand until the discharge ceases. In some of the cases when cured the antiseptic may keep up an irritation. If suspected, the lotion should then be changed for boracic.

In some of the large public schools, where acute conjunctivitis of a severe type was common, its disappearance has been connected with the addition of copper sulphate, one part in a quarter million, to the swimming-bath water. Now " pink eye " is said to be rare under these conditions.

The effect of Medical Inspection on the group of ophthalmia is most marked, and was well illustrated when the supervision of scholars by their own advisers was replaced by school doctors in Genoa (Ragazzi, *L'Igiene d. Scuola,* 1918. 61).

The majority of cases are due to the Koch-Weeks bacillus, which does not colour with Gram stain. Occasionally limited outbreaks of a milder kind are found due to pneumococci, and the so-called angular conjunctivitis due to the Morax-Axenfeldt bacillus.

Phlyctenular Conjunctivitis.—In the class of unhealthy ill-nourished children, often blocked by enlarged tonsils and adenoids, already noticed as liable to blepharitis, a form of sub-acute conjunctivitis occurs with formation of small, hard, raised papules on an inflamed base. These phlyctenulæ often appear singly, near the corneal edge, and sometimes on the cornea. There are two varieties distinguished: herpetic, generally accompanied by nasal obstruction, and said not to be sensitive to touch; and the phlyctenulæ, which are sensitive to touch and often to light, which are possibly due to tubercular toxins. In any case the pulpy, unhealthy-looking children with lymphatic engorgement that is commonly called strumous seem liable. These are anæmic, badly fed children, living largely on carbohydrates and generally in need of fresh food and more exercise. The last need explains why it seems common in girls.

A phlyctenula on the cornea is liable to break down into a little ulcer; inflammation about the base, however, prevents septic infection extending, and the ulcer ultimately heals, leaving a scar which may interfere with vision either by causing corneal irregularity or a small, bluish-white cicatrix.

These phlyctenular ulcers are about the most visually damaging of chronic eye troubles in the first half of school-life. Atropin and yellow ointment help to clear up the attack, but constitutional treatment is also necessary to prevent relapse. Improved hygiene —the seaside home, for instance—causes rapid improvement, but return to old surroundings means a likely relapse.

Cases, whether with phlyctenular ulceration or photophobia, should not be in school. Some used to be seen wearing darkly coloured spectacles. Blue, amber or London smoked were supplied for such conditions, but since these have been forbidden for school use their prescription is much rarer.

The result of a central ulcer in an unhealthy child during measles, seen later in school, is a slight opacity which from its position is

very damaging to vision. They seem to be getting more uncommon in recent years, as a result of improved nutrition and early care.

Granular Lids or Follicular Conjunctivitis.—Among unhealthy children, after acute or sub-acute conjunctivitis, a chronic condition occurs, spoken of as granular lids. It was first described by Professor Greef in Germany as "school folliculitis." Follicular conjunctivitis describes the small lymphatic follicles and reddened velvety granular condition marked on the conjunctiva of lower lids, and rare on upper lids except in very mild degree, when trachoma would be suspected. The lymphatic follicles appear as quite small reddish or yellowish granules. A mild degree is present in many children who suffer from chronic adenoidal catarrhal conditions. There is stickiness and secretion of the lids in slight cases. The Koch-weeks bacillus is often found in the secretions. Attention to general health, and use of astringent applications, such as 0·2 per cent. zinc sulphate in boracic lotion, clears up the condition, leaving no trace of trouble. Glasses are said to help, as in other cases of chronic conjunctivitis. The child should not be in school while suffering, although the condition cannot be considered infectious.

In ancient Rome children put oil in their eyes in order to be turned out of school (*Persius Sat.*, III. v. 44). They may have been mimicking a more serious disease from which granular lids has to be differentiated—that is, trachoma. Indeed, folliculitis may not get any worse, and even proceed to slowly improve. The condition may also become more inflammatory-looking; the lids redden, thicken and get dull on the surface, and finally develop into unmistakable trachoma.

Trachoma.—This disease is now rare in England, yet is one of the scourges of humanity. It is common in Russia and Poland and all over the East. Half the school children in Egypt are affected. There most of the blind and one-eyed are due to it. There are districts in America where is flourishes, especially among the Indians and in their neighbourhood. It is common in Australia, Queensland especially.

In a Census of Blind in 1920 in the State of Missouri, taken for the Missouri Blind Pensions Act, 19·7 per cent. of blindness among 3563 over the age of 21 was due to trachoma—that is, 1406 cases. The school children of Southern Illinois had 2 per cent. trachomatous in 1921.

Although isolated cases occur whose origin cannot be traced, the writer saw many more cases in Swansea than in a larger eye practice in Bradford; and in London, cases are very rare except in aliens and their children. It has always to be suspected with folliculosis or granular lids.

Formerly the two diseases were confounded. Until recently some held the theory that the two conditions were varieties of one disease.

Trachoma begins as a slight conjunctivitis due to infection from another case. The agent of infection has not been recognized.

A member of a family may have chronic trachoma for months or years and the others be unaffected. Smit and Wilbaut found in Amsterdam that the family was the main source of infection, and that infection generally occurred before 6 years old. School only played a small part. Its prevalence is increased by bad housing conditions even in country districts. Several cases may be found in children of one block of flats ; whilst a couple of cases in the same school class would be uncommon. A mother with trachoma for 21 years says her children aged 6 and 7 have only suffered for three months. It might be highly infectious, especially in acute cases with much discharge. Both nurses and doctors were included among those who contracted it in clinics under the New York Bureau of Child Hygiene.

The disease is established clinically before it can be otherwise recognized. Conjunctivitis progresses till the surface is bluish and gelatinous looking, but when the lids are everted it is dull with the texture of the finest sand-paper, and with reddened inflammatory thickening and drooping of the eyelids. The red velvety, but fleshy-looking, granular conjunctival surface of the lids is evident. Although there may be remissions and exacerbations later, granulations are seen on everting the upper lids. The trachoma bodies shew up after a time, at first yellow, then white, then as greyish granules up to the size of a large pin's head ; when bigger they are irregularly polygonal. Patients often have a curiously tired, sleepy look about the eyes, quite characteristic when seen. Gradually, scarring and cicatricial bands form, and later the lids sometimes become deformed. The conjunctiva on the globe may undergo thickening as pannus over the cornea, almost blinding the patient. It is possible for only one eye to be seriously affected.

The less discharge, the less infectiousness. A cure, however, can only be judged on freedom from discharge, absence of redness, of dilated conjunctival vessels, and disappearance of all follicles and papillæ. Photophobia, lachrymation, pain or discomfort should have gone. There is no fear of recurrence if the eye has been well for six months.

Every case should be under treatment as soon as possible. The common treatment is regular persistent use of silver nitrate at first, and later astringent copper sulphate stick, with expression of granules by surgical means. Proper treatment gives considerable relief, and for a time reduces danger of contagion, so that mild chronic cases are allowed to attend school in New York.

The differences between granular lids and trachoma as set out by Cohn, who had enormous experience of both in Breslau, was that sago-grain bodies of greyish colour in trachoma were at least

double the size of small reddish or yellowish granules in folliculitis. Again, trachoma affects upper lid as well as lower, whereas in follicular catarrh the upper lid is scarcely affected. Granulations in the upper cul-de-sac are almost certainly trachomatous. Lastly, there are no cicatrices in folliculitis such as mark the later stages of trachoma.

American workers distinguished the conditions (*J.A.M.A.*, 1920. ii. 1119): with folliculosis the capillaries of the conjunctiva are not hidden, but can be distinctly traced up around the edge of the follicle; whereas in trachoma, these vessels are more or less obscured, and it is not possible to trace them uninterruptedly to the cul-de-sac, which would be possible in the absence of hypertrophy.

Granular lids will respond quickly to treatment by yellow ointment, which has no effect on trachoma. Trachoma is so serious that is should be guarded against whenever there is the slightest doubt. Cases had been rare in London schools, not more than five or six cases annually for at least a score of years, when suddenly in the Spring of 1924 numerous cases began to appear from the

Table 65.

NEW YORK CITY.

	1910.	1916.	1920.	1923.
Trachoma	20,915	8798	944	327
Conjunctivitis	26,855	26,942	7588	4732

East End, and 215 were recorded before the outbreak came to an end by removing the cases to the Residential School at Swanley.

It must always be regarded as an ever-present risk which may easily become a serious scourge, and a reproach to any health system which permits its prevalence. Whilst it is eminently curable as a community disease, it is particularly intractable as an individual affection. It should be notifiable, as it has been in Glasgow since 1915, and definite official arrangements made, including grants for its free treatment and control, if necessary by isolation of infectious cases. Travelling clinics may be a necessity for rural foci. The Report of School Medical Inspection in New York City for 1920, compared with ten years previously, shews what can be done in the way of eye hygiene. In Athens, Dr. E. N. Lampadarios reports trachomatous eyes as among school children: 1918–19 = 4·58 per cent., 1919–20 = 3·06, 1920–21 = 1·02, and in period since, 1921–24 = 0·05 per cent.—an improvement due to sanitary service in schools, and school clinics.

Other External Troubles.—A rarer condition hardly to be con-

fused with trachoma, and found in debilitated cases, is a drying of the conjunctiva. All cases seen by the writer were of Irish parentage, and in reformatories or orphan institutions. There may appear small horizontally placed white triangles of deposit with their bases against the corneal edge, and with the apex pointing to the canthus. These are caused by accumulations washed into that position by the movements of the eye and lids. The white material is degenerated epithelium and masses of a diphtheroid organism, the xerosis bacillus. The cornea later becomes affected and hazy. The patients are poorly nourished, and those old enough to notice complain of seeing very badly in reduced light. The retinal structures affected are becoming night blind. Sydney Stephenson (*Brit. Journ. of Child. Dis.*, 1911) thinks cases occur chiefly in Summer and Autumn.

This condition, although uncommon, is characteristic, and should be recognized at once by a school doctor. Similar conditions, with softening of cornea, were noticed during the War in children lacking certain elements in their food, and can be artificially produced in rats by dieting (p. 107). The condition is quickly relieved by milk and cod-liver oil. It has to be differentiated from the night blindness of retinitis pigmentosa, where there are very contracted visual fields and no white patches of xerosis bacilli material on the conjunctiva.

Styes.—Another happening in debilitated children is infection of one of the sebaceous glands in connection with hair follicles, forming a small boil, the stye or hordeolum. From its position it is frequently very painful. Hot fomentations, and sometimes squeezing out the contents through the follicle, with use of yellow ointment, may prevent full development. Usually a small abscess with a core forms, and may have to be opened as soon as possible. There is risk of further infection, so that a series of such styes may occur. Constitutional treatment by cod-liver oil, tonics, and change to the seaside or country is almost always a benefit. The existence of a stye is evidence that the child's immunity is too low.

Interstitial Keratitis.—Whilst with various kinds of conjunctivitis, the cornea may have slight damage which is optically serious for vision, phlyctenular conjunctivitis is usually accompanied by much photophobia and blepharospasm. In children with a strain of congenital syphilis a keratitis may appear, varying in results from the faintest haze to a dense opacity, from interstitial deposits in the layers of the cornea. Small grey spots are seen about the centre, just a little cloudiness spreading towards the periphery, and generally laterally. If neglected, these coalesce, small vessels appear, and the cornea gradually becomes thick and salmon-coloured in streaks, and vision is reduced to counting fingers. The surface is hazy but not ulcerated.

These cases are amenable, in some degree, to the modern treatments for syphilis, more so than the deafness which sometimes accompanies them. The cases seen in scholars may last for months or years, and, whilst not totally blinding, may result in ineffective vision. The British Council of Ophthalmologists have drawn attention (1923) to unsatisfactory results of out-patient treatment of these cases, which really need the residential hospital school if vision is to be safeguarded.

Specific interstitial keratitis is one of Hutchinson's triad, with deafness and notched incisor teeth, the syndrome of congenital syphilis. Although well known, the combination is not common. The earthy complexion, depressed bridge of nose, scars at the angle of mouth, are other indications of inherited conditions. Sometimes one child in the family presents notched incisors, and may be with a brother or sister shewing keratitis. There may

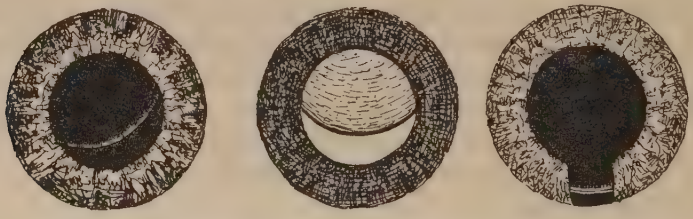


FIG. 91.—CONGENITAL DISLOCATION OF LENS.

On left as usually seen with edge of lens just shewing, in middle as seen by illumination with retinoscopy mirror. Figure on right shews coloboma of the iris downward, and edge of lens just shewing.

also be a family history of miscarriages, still-births, or early deaths. The indications have to be watched for, but popular statements as to obvious prevalence of congenital syphilis among school children are exaggerated. This specific keratitis, however, is a greater cause of visual damage than ophthalmia neonatorum. Harman, from considerable numbers of London children, found the gonorrhœal blindness from ophthalmia neonatorum in the seven years before the War, 1907–13, as 18·3, and from congenital syphilis as 46·8 per 100,000, the rates for 1914–20 being 12·5 and 40·2 respectively.

The Pupil of the Eye.—The pupil may not be central; there may be small congenital persistent threads across it, though they are infrequently noticed by the school doctor. The pupillary edge may be notched or serrate from old adhesions due to inflammation, iritis. There may be coloboma of the iris, a congenital condition looking as if an iridectomy had been done downwards, or up or in. The edge of the lens may often be seen in such a coloboma. There may be aniridia, rare absence from want of development of the

iris, which is only represented by little thickened knobs. The lenses are occasionally dislocated from birth and sometimes seriously interfere with vision.

The lens' edge can occasionally be seen on inspection, and examination in the dark room with the ophthalmoscope shews the edge as a dark curved line in one part of the pupil.

Sometimes the pigment of the eye is wanting, and indeed pigment in the body generally, so that the blood vessels shew as

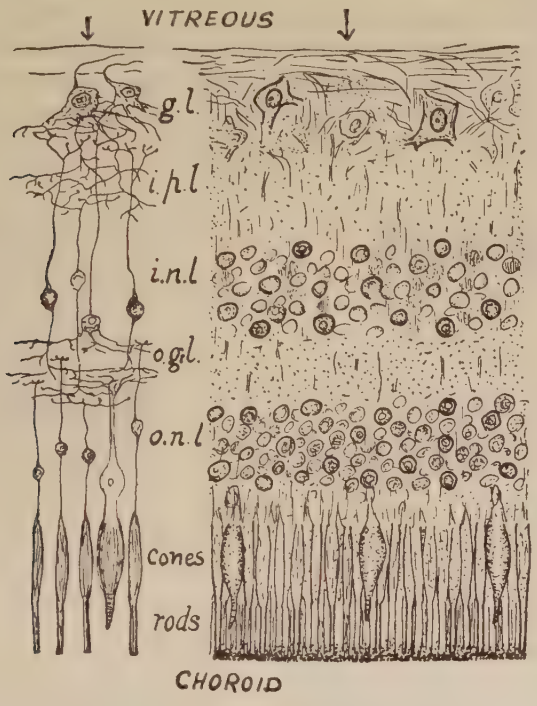


FIG. 92.—GENERAL PLAN OF RETINAL STRUCTURE (× 700).

Shewing *g.l.* ganglion layer, *i.p.l.* inner plexiform layer, *i.n.l.* inner nuclear layer, *o.g.l.* outer granular or plexiform layer, *o.n.l.* outer nuclear layer, and rods and cones.

a pink reflex in the pupil, and the iris is very light or even pink in tint in albinos, who also have white hair.

The Process of Seeing.—Normal healthy eyes at rest and looking straight forward have a clear picture of what is in front formed on the retina. The picture, by different quality and quantity of light in its various parts, affects the retina. This, from its nervous elements, sends a volume of impulses through the optic nerves to the visual centres in the occipital lobes, from whence they are transferred to other regions of the brain to be built into impressions which are the foundations of mental life.

The retina is composed of: (*a*) layers of dark pigment cells, the choroidal pigment; (*b*) a layer of rods and cones, the percipient elements; (*c*) a layer of nervous structures, neurones and their axones; this layer is disposed in various strata somewhat as in the cortical structure of the cerebral hemispheres. They form relays between rods and cones, and cerebral ganglia.

Taking the middle layer, rods and cones, first: cones apparently have something to do with exact form, rods with general light perception and colour.

If the rods and cones layer is looked down on from the centre of the eye, it would be like a tesselated pavement, at the periphery mostly rods with a rare cone here and there, cones getting more abundant as the macula is approached. The macula is scarcely a couple of millimetres across, and the nervous layer gradually ceases

FIG. 93.—RETINAL ADAPTATION, AND CHANGES IN POSITION OF THE PIGMENT GRANULES ABOUT RODS AND CONES.

here except for rods and cones, and the pigment layer. The rods are few, cones many, till the fovea centralis, the yellow spot about a quarter of a millimetre across, is reached; here there is nothing but cones. This is hundreds of times more sensitive to form than any part of the retina beyond the macula. The rods at rest accumulate in their body a chemical compound, the visual purple. This is bleached rapidly by action of light, and it is this which seems to initiate the function of vision.

When eyes are in the dark and protected from light, this visual purple accumulates; when exposed to light, it is gradually exhausted —the eye becomes fatigued.

Another action also takes place; the choroidal pigment cells which fit like caps on the peripheral ends of the rods and cones send processes up surrounding them. These cells and processes are loaded with black pigment granules. When eyes are protected from light, these processes are retracted; but when exposed to light, they are protruded to shield or shelter the rods and cones, or else to help to re-establish the visual purple.

When they are withdrawn, the eye is exceedingly sensitive to light. It is said to be dark-adapted. This is a process that takes about ten to fifteen minutes to accomplish, but still goes on a little up to half an hour or more, quicker, presumably, according to good health and brisk blood and lymph circulation of the individual.

When the processes are fully protruded, as in bright sunshine, the eye is hundreds and thousands of times less sensitive than when dark-adapted.

Adaptation occurs to a greater extent at the centre than the periphery of the retina. If one walks into the dark and looks directly at a luminous watch, nothing is seen, the macula being not yet dark-adapted ; but on moving the eye to look a few inches away from the watch, its gleam is perceived. The time cannot be determined, as the periphery of the retina which sees the image whilst less light-adapted, is also less sensitive to form. In a minute or two, on looking at the watch, the time can be seen, as the macula has become dark-adapted and is now more sensitive and distinguishes the figures.

This light-adaptation of the eye is of great importance in school problems and must be grasped if illumination is to be understood. In the daytime an electric lamp can burn almost unnoticed, which at night could not be endured for its glaring blaze, although the amount of light it is giving out remains constant. One walks boldly out through passages from the dungeons of a Norman castle, where one groped the way in, because in the interval the eyes have become dark-adapted and gained hundreds of times in sensitiveness to light.

Another reaction against excessive illumination is quick response of the pupil. The iris contains two sets of non-striated muscle fibres, radially and circularly disposed, which are set into action by light falling on the retina, causing the pupil to diminish in size. This contraction takes place instantly on exposure to a bright light, and slowly relaxes as the retina becomes adapted to light. There is always a slight amount of contraction in light, and dilatation in dark. Reactions of adaptation and contraction of the pupil to light are reflex actions, beyond control voluntarily, and always present unless some diseased condition prevents them.

Accommodation of the Eye.—The above described mechanisms are protective to the retina. To aid action in vision there are other arrangements to form exactly on the retina a clear image of the object.

The normal eye measures about 23 mm. from centre of the cornea to centre of retina. The various refractive surfaces of cornea, aqueous humour, lens and vitreous are so arranged that parallel rays from an infinite distance, which in regard to the size of the eye means any distance more than six metres off, are focussed into an exact picture on the retina. Rays from nearer objects are

divergent, and the refractive power of the eye at rest is insufficient to bend them enough to focus clearly on the retina.

The greatest effect in refraction is produced by the lens, and as rays passing through the centre of a lens are more accurately focussed than those passing through the periphery, in looking at near things the iris acts as a diaphragm and cuts off the extreme peripheral rays, which might otherwise blur some of the image formed, thus minimizing spherical aberration.

When looking at a distance, even with only one eye, and then at some object in the same line but nearer, there is a sense of effort. Something has been done in the eye, the near object is now seen distinctly and the distant object not so well. The image from the near object has been focussed clearly on the retina, whilst the image of the distant object has gone out of focus. This is managed by accommodation of the lens. The lens has gained in its power of bending diverging rays from the near object, and they now focus exactly on the retina.

The mechanism of accommodation depends on elasticity of the lens, which is built up of layers of clear fibres, enclosed in a transparent capsule under considerable tension. The capsule is suspended in the opening in the globe which has the collar of ciliary body round.

Helmholtz shewed that muscular fibres in the ciliary body can cause this to be drawn slightly forward and towards its centre, so that the tension of the suspensory fibrils on the capsule is a little relaxed, and elasticity of the lens comes into play. It thickens at the centre, the anterior surface becoming more curved. Recently his explanation has been confirmed and refined by Fincham (*Trans. Optical Society*, XXVI. No. 5), who shewed that varying thickness of the structure of the capsule had a considerable effect.

The amount of this accommodation exerted is just sufficient to get a defined image of the object looked at. Associated with this accommodation is an amount of pupillary action to compensate the spherical aberration of the lens, more noticeable with diverging rays, the pupil being a little contracted when near objects are seen, compared with its condition when looking at a distance.

The image of the object looked at should fall on the macula, which is more sensitive to shape and form than the rest of the retina. This is done by the action of six external muscles. They turn the globe so that the optic axis—which for practical purposes may be taken as the line through centre of cornea—lens, and macula also passes through the object looked at. These movements are so automatic, free and unceasing, that no one realizes what a small extent of field of vision is seen clearly at once. Unceasingly the eye is running over an object looked at, and piecing together images in the mind to form a conception of the whole.

If only one eye be used, and a newspaper held up a foot off,

making a small dot on the paper as an object to fix the direction of vision, it will be found that whilst the eye is kept fixed and not allowed to wander, the area of newspaper over which single letters can be clearly distinguished can probably be covered by a sixpence, certainly by a shilling.

Dr. R. J. E. Hanson worked out, during the War, that at 40 cm. from the nodal point of the eye, which is a point on the axis 15 mm.

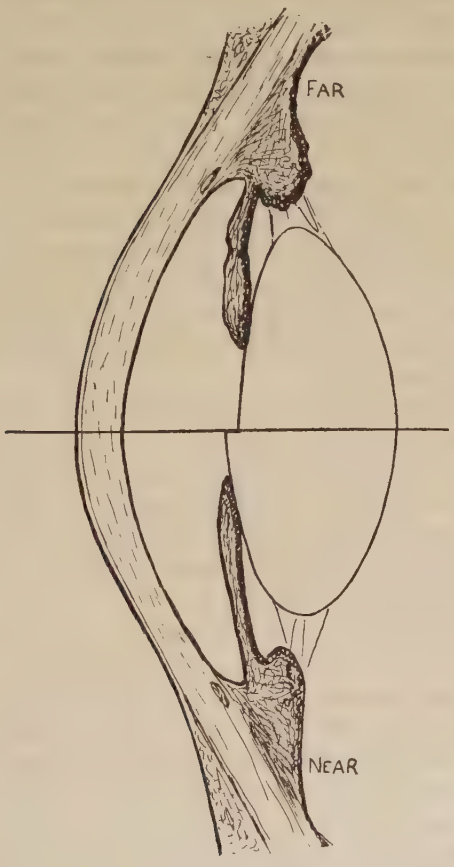


FIG. 94.—THE CHANGES IN ACCOMMODATION.

in front of the retina, the fovea covered the field 7·5 mm. horizontally, and 5·0 cm. vertically. The macula corresponded to 7·5 cm. horizontally, and 5·0 cm. vertically. That is the area whose image falls on the macula. When one comes to consider reading and print, this consideration can be usefully remembered, as illustrated by the newspaper print, and also by Dr. Hanson's calculation (Fig. 107).

So far, only one eye has been regarded ; but images are formed in both eyes. Whilst eyes are at rest their axes are parallel, and

distant objects clearly seen. When near objects are looked at, the optic axes are no longer parallel; they are adjusted so that each axis passes through the object, which means that they converge and intersect in the object.

This is called convergence of the eyes. The work falls mainly on the internal recti muscles. The amount of convergence means increased muscular work, and increases with nearness of the object looked at. From long association convergence and accommodation have got so linked together that they are proportioned, and the convergence amount corresponds to accommodation and vice versa.

Measurement of Accommodation and Convergence.—With normal eyes, objects seen at an infinite distance are clearly imaged on the retina. If an object is only a metre away, accommodation has to be exerted, the eyes have also to be converged. If the object is only half a metre off, then still greater convergence and more accommodation has to be effected. So far as accommodation is concerned, this is equivalent to making the lens more powerful by action of the ciliary muscles allowing its elasticity to come into play. The amount can be measured in terms of lenses which can be used to replace the accommodation.

It is possible temporarily to paralyse the internal muscles of the eye. A drop of solution containing 1 per cent. of homatropine, in half an hour paralyses the internal muscles so that the eye cannot accommodate, and the constricting circular fibres of the iris being also affected, the pupil dilates. This dilating effect is known as mydriasis, and agents like belladonna alkaloids, which dilate the pupil, are referred to as mydriatics.

The normal eye under a mydriatic will see distant things perfectly well, but can only see an object clearly at a metre away if viewed through a convex lens of one metre focus. The bending powers of such a lens are then equivalent to the accommodation exerted when the eye (without mydriatics) accommodates for an object a metre away. The strength of the lens is called one dioptre. If the object was only half a metre away, a stronger lens would be required whose focal length was half a metre and its strength two dioptres. The strength in dioptres of any lens which is equivalent to accommodation exerted to see an object at corresponding distance will be obtained by dividing a metre by the focal length of the lens or what is the same thing.

$$\text{Dioptric strength of lens} = \frac{100}{\text{focal length in centimetres}}$$

$$= \frac{100}{\text{distance from eye of object looked at}}$$

$$= \text{Accommodation in dioptres of normal eye for object.}$$

The accommodation and convergence being proportioned to work exactly together, convergence can also be stated as equal to so many dioptres where the dioptres,

$$\text{Dioptres of convergence} = \frac{100}{\text{distance of object from eye}}$$

Functional Differences between Juvenile and Adult Eyes.—The eye grows from a flattened mass of tissues in the fœtus, and its rate of growth is normally proportioned to that of the brain. It grows at an enormous rate at first, gradually slowing. By about

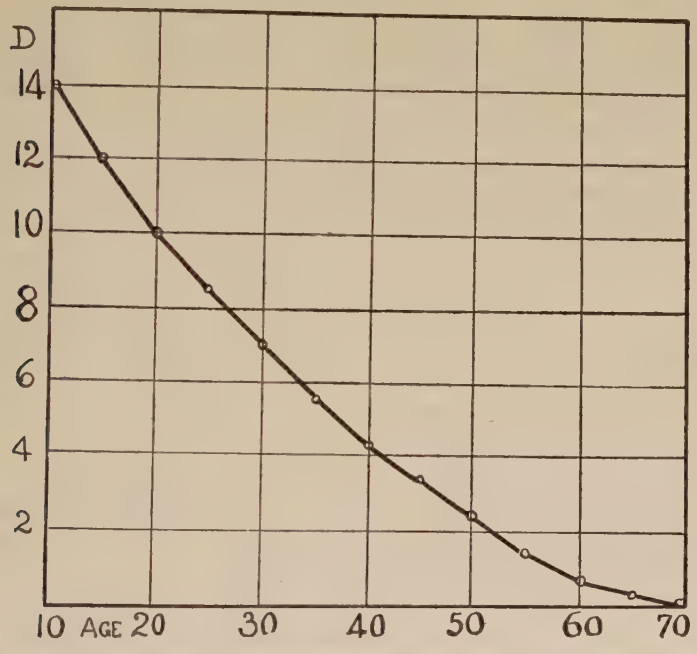


FIG. 95.—RANGE OF ACCOMMODATION AT VARIOUS AGES.

7 years old it has reached within 3 per cent. of its full weight. In the young child with undeveloped eye, the lens is very elastic and accommodation easy. With increasing age, the power of accommodation decreases, as the lens, becoming less elastic, fails to bulge out as fully when the tension of the capsule is lessened.

The total accommodation capable of being temporarily exerted at the age of 10 is about 14 dioptres ; by 15 years old, this is 12·5 dioptres ; by 20 years, 10 dioptres ; at 30 years, 7 dioptres ; and at 45 years old, 3 to 3·5 dioptres. But for continuous work the ciliary muscle cannot work anywhere near this. About one-third the amount is within safe limits, without producing annoyance and pain.

The great power of accommodation in childhood decreases

steadily, and by late middle life fails. For the normal person, reading-glasses become necessary to aid or replace the failed accommodation, a condition called presbyopia. The young child has to accommodate to see clearly with its undeveloped eye, and this is largely true, too, of inferior races of mankind who live a wild, savage life and have eyes of an immature type.

For every millimetre that the axis is short of the normal 23 mm., there is required an extra 3 dioptres of accommodation. This condition, where axis is too short, or retina relatively too near the lens, is called hypermetropia.

A young child in endeavouring to look at a distant object has to exert a little accommodation; if the object is near, he has to exert still more, and his power of working two eyes together is not very great. If he endeavours to see well, he accommodates (i) to compensate for the shortness of his eyeball, and (ii) to compensate for the nearness of the object. He only needs to converge for (ii), but tends to converge also to the proportionate amount for (i), with the result that there is this amount of excessive convergence, and then there would be two overlapping images, one for each eye. Only the image is attended to, in the eye which fixes the object—that is, which has its optic axis passing through the object. The other image is neglected or suppressed and there is inward squint of the unused eye. All children in the babies' room, if carefully observed, soon shew some temporary squint when set to do near work.

This convergence mechanism is of enormous importance. The fields of vision of the two eyes overlap. In most animals the two eyes look out in separate directions, but with increasing cerebral development the visual fields approximate and overlap more and more. This attains its highest development in the bifoveal vision of the human eye. Where convergence is not developed, apart from its occurrence with other eye defects, such as hypermetropia, there is sometimes want of full cerebral development amounting to feeble-mindedness.

The most useful observation of the school doctor beginning work is to sit for half an hour in an infants' school where some of the old kindergarten work, such as "embossing," threading beads, or sewing, is being attempted. The postures of the children, effects on their eyes and tongues, and early evidences of fatigue, and then of boredom, are all instructive, especially if nothing is said, but every few minutes notes are made unobtrusively of the various children's doings.

Even in Standards I and II children learning to read will hold their books a few inches from their noses when, if any single child be tested, he will be able to see letters 12 or 15 in. away. He does this to save fatigue. To see clearly, with the book a good

distance away, means effort of accommodation. Then a clear, small image is formed on the retina, and a comparatively small volume of nervous impulses travel up to the brain.

If the book is held 4 in. off, instead of twelve, there is less leverage on the arms, but also accommodative strain, and the child sacrifices his clear image and saves the accommodative strain. He sees a very large image not so clearly, but a voluminous message goes through to the brain, probably saving some mental effort, and although the image seen is more indistinct, yet it is easily recognized. The comparison between using the high and low eyepieces of a microscope might be suggested.

A child who sees a pin yards away on the floor still grubs with his nose in his book, and his head bent over, compressing his chest and rounding his back, really to save fatigue of accommodation and other muscles. This leverage of the arms, too, if the book is held in the hand, means an impossible muscular strain, unless the arms are rested on the chest. The arms of a young child, indeed, are not long enough to hold a book at the proper distance. The hypermetropic eye is this shortened, undeveloped condition seen in the young child, and among savages, where accommodation is exerted to see even distant objects.

The theoretic condition of the eye at rest, forming a clear image on the retina, is the ideal perfect eye which scarcely exists, except as a transient phase of growth. The condition is described as emmetropia, and the eye emmetropic. With continued use and growth, as time goes on, the eyeball may stretch so that the axis is relatively longer and the furthest point at which print can be seen clearly comes nearer to the eye. This condition is closely associated with civilization. As persons who have such lengthened eyeballs often half-shut their eyes in the endeavour to see afar, it is called myopia, or short sight.

The Visual Acuity.—V.A. is determined by minimum distance at which two simultaneous impressions give two distinct sensations. Snellen, who worked at standardizing tests for visual acuity, found average vision was that which distinguished three parallel black lines on a white surface, when they were separated by their own breadth, and the whole subtended an angle of 5 minutes. On this as a basis he constructed test types to be seen at different distances, and expressed visual acuity as the reciprocal of the smallest visual angle at which test letters can be clearly seen.

If D is the distance at which they subtend a 5-minute angle to the eye, and d the distance at which they are clearly seen,

$$\text{V.A.} = \frac{d}{\text{D}}$$

To eliminate accommodation, the test is always taken with

distant type. The types are constructed so that by taking the distance d as 6 m., the letters of each line of type downwards subtend 5 minutes at 60, 36, 24, 18, 12, 9, and 6 m.; sometimes 5 and 4, are added. If the child reads to the fourth line, its vision is $\frac{d}{D} = \frac{6}{18}$. The visual acuity should always be expressed in this crude fraction, the top number giving the distance in metres, and the denominator the distance of the smallest letter distinguished when seen at an angle of 5 minutes. It is printed on the test card just above the line.

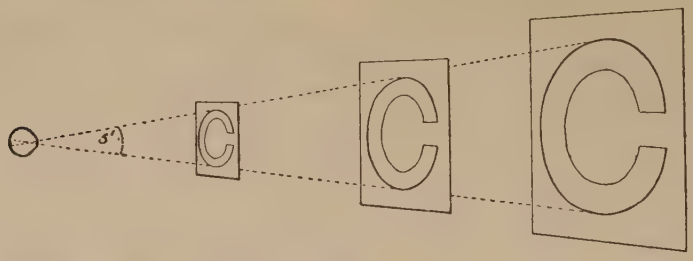


FIG. 96.—MEASUREMENT OF VISUAL ACUITY BY SIZE OF OBJECTS AT VARIOUS DISTANCES.

Unfortunately, in America and Germany, through insurance compensation values being so estimated, there is a tendency to express visual acuity in reduced figures as a decimal, which fails to give full information, for school purposes.

The size of the letters, to subtend 5 minutes at any distance, can be easily calculated: for tan $5' = 0{\cdot}00145$, and this is equal to the height of square letter in millimetres, divided by distance of the eye in millimetres.

For Snellen's Test Types at 6 m., these measurements are—

TABLE 66.

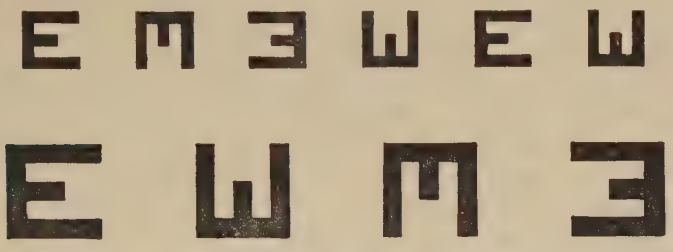
SNELLEN'S TEST TYPES.

Metre letters ..	60.	36.	24.	18.	12.	9.	6.	5.	4.
Thickness of letters in mm.	17·45	10·47	6·98	5·22	3·48	2·61	1·74	1·45	1·16
Visual angle at 6 metres	10′	6′	4′	3′	2′	1′ 30″	1′	50″	40″

Taken all round, Snellen's Egyptian block letters form the best test. Others have altered the form, making them plainer, but this is not to the purpose. As all letters are not equally legible, Cohn used the plain block letter E in various positions. This is

an excellent test for young children and illiterates, but here the wide opening of the E helps legibility, and the letters are not distinguished purely by the 1 minute thickness of the limbs.

Landolt used rings with a break of 1 minute. He calculated these for various fractions of visual acuity. They were recommended by the International Ophthalmological Congress in 1909.



They have been adopted by Dr. MacCallan for use in Egypt, according to Snellen's scale, and are perhaps the most perfect test forms, the breaks occurring in different radii.

Table 67.

Distance in metres	6.	9.	12.	18.	24.	36.	60.
External diameter of circle in mm.	8·7	13·05	17·4	26·1	34·8	52·2	87·0
Size of gap and thickness of circle in mm.	1·74	2·61	3·48	5·22	6·96	10·44	17·44

The broken ring can be arranged on a circular card with a small pulley behind, to change its position for school use by pulling a string. For illiterates various other objects, such as portions of the hand, or dice faces, have been used. Harman has suggested a signal test; figures with fingers stretched out, and various fingers extended (*B.M.J.*, November 1913).

It is important that the test types are correct in size. B. A. Randall (*Buffalo S.H. Congress*, 1913. v. 91) found many test cards with letters too large, some as much as 12 per cent. in excess. One must also remember that the acuity taken is a working average; much finer discrimination is possible (p. 479).

Children's vision was first extensively tested in 1894, in the schools of Bradford. The writer had to obtain the maximum result cheaply, and be economical of his own time. This was done at a trifling cost by using a copying exercise as a means of testing, and by assuming that binocular vision was sufficient for school purposes.

The Bradford Method.—A test card was constructed on Snellen's method, with the letters adapted for use at any round distances between 30 and 10 ft. It was assumed that the small accommodation required for these distances might be neglected in children. The children sitting in their desks in the class-room wrote their name, age, date, and Standard on a prepared form. In a square on top right-hand corner of the form they wrote a number told them by the teacher. The card was hung at a measured distance from the front desk, somewhere between 10 and 12 ft. The number at the top of the form was distance in feet of desk edge from test card. The children then copied all the letters they could from the card, and by going over the papers later, and marking the letters incorrectly copied, the visual acuity was sufficiently determined to give a first selection of cases for ophthalmic examination (*Journ. Roy. Stat. Soc.*, 1897. 644).

Bradford testing was carried out in the months of April or September, when there was good daylight.

Dr. Palgrave (Middlesex, 1910) found that visual acuity returns varied from 78 per cent. normal in mid-Winter to 88 per cent. in Summer.

The Board of Education Regulations ask for detailed examination of each eye, although it is very doubtful whether the results in the mass are worth the greatly increased expense.

W. Inglis Pollock (*B.M.J.*, October 2, 1909), a careful investigator, approves of using both eyes simultaneously for school tests.

If the results of examinations are recorded by fine divisions ($\frac{6}{6}$, $\frac{6}{9}$), certain precautions are necessary. A class sitting in a room with sunlight in it, especially after a reading lesson, is likely to shew poorer results than if not occupied on particular eye work, and in a less brightly lighted place. Children previously noted as normal have been selected in secondary schools by their teachers as having bad vision ($\frac{6}{9}$ or $\frac{6}{12}$), and on being carefully re-tested have had vision nearly normal. This is due to temporary spasm of accommodation.

The position of the test card, about 6 or 8 ft. from the floor, should not be near any brightly lighted, visible object or source of light. It should never be exposed, except in use, and should be clean and well lighted. The minimum illumination is three foot-candles, but any likely amount above this is satisfactory. The room should be fairly illuminated. Too bright light may narrow the pupil and sharpen definition.

For standard tests the Council of British Ophthalmologists have set out a specification. They suggest always using artificial illumination. Two ordinary 20-watt tungsten lamps are fixed vertically 15 in. in front of the plane of the card, one on each side at a horizontal distance of 12 in. from the normal vertical

plane bisecting the card. One lamp is opposite the junction of upper and middle third, the other opposite junction of lower and middle third of card. Opaque non-reflecting screens are fixed to prevent direct light reaching the eye.

The child to be tested is brought up to a mark at a fixed distance, preferably 6 m. from the test card. Covering the unused eye with a card or small screen on a rod, it is told to read the letters, beginning at the top and going on until it cannot read any more. The visual acuity is then represented by 6 m., divided by the distance in metres at which the smallest letters correctly read should be read by the normal eye. This is the distance printed on the card in fine letters above each test line.

What is here tested has not yet been thoroughly investigated psychologically, but the younger the child, the less a visual and the

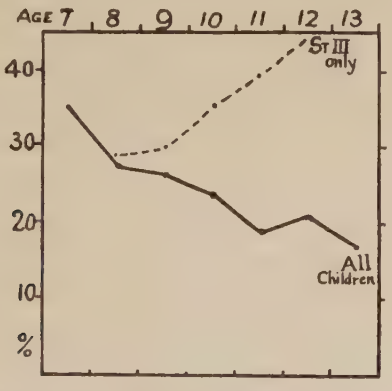


FIG. 97.—DEFECTIVE VISUAL ACUITY AT VARIOUS AGES IN BRADFORD SCHOOLS.

more a mental factor is tested. This shewed up in the first testing in Bradford. Visual acuity improved steadily with age when all children were taken, but when only Standard III children, presumably about the same mental level, were used, then the older and more backward the child, the worse the visual acuity record. This was mostly due to the psychological element not fully appreciated at the time. The figure illustrates these observations.

In the earlier school-work it appeared as if visual acuity improved with age, but, by proper precautions, loss of acuity is least in the baby class. An enquiry in 1905 (Sayer, Kerr, and Critchley) on 2782 infants has shewn the results in percentages (Table 68).

In this enquiry it was suspected that the mental element had not been sufficiently allowed for, and that results were possibly 20 per cent. too great. Knowing this, re-investigation was made in 1913 by Dr. Margaret Hogarth in London on 800 children between 4 and 7 years of age. At first the child was given a large card

with E to hold in the same position as the test letter. The mental process was found too complicated, and arm movements were substituted. Finally, the E was taken into the school routine. The children drew it, cut it out in paper, and then, when thoroughly familiar with E in every position, they went through the vision tests

TABLE 68.

Ages	6–6½.	6½–7.	7–7½.	7½–8.	8–8½.
Fair Vision, $\frac{6}{9}$–$\frac{6}{12}$:					
Boys	16·4	17·1	13·1	18·4	16·6
Girls	13·3	13·2	17·8	13·0	20·0
Children	14·8	15·2	15·1	15·3	18·0
Bad Vision, $\frac{6}{18}$ or worse:					
Boys	3·3	6·3	6·1	6·5	8·2
Girls	3·6	4·6	5·2	6·3	7·5
Children	3·5	5·5	5·5	6·4	7·8

easily and quickly. Even then a child that stuck with the mental effort over small letters soon read an extra line or more with the promise of a sweet to induce the added effort needed.

Rapid onset of fatigue in undeveloped brain centres was evident, especially in the afternoon. A brown paper with a hole cut in it, to cover the test card and isolate the test letter, concentrated the child's attention, and apparently sharpened its visual perception, really its apperception.

Bright daylight was used, and illumination on the test card measured with a lumeter before and after the tests averaged 70 foot-candles.

TABLE 69.

DR. MARGARET HOGARTH'S INVESTIGATION OF 800 CHILDREN.

Age.	Numbers.		$\frac{6}{18}$.		$\frac{6}{12}$.		$\frac{6}{9}$.		$\frac{6}{6}$.	
	Boys.	Girls.	Boys.	Girls.	Boys.	Girls.	Boys.	Girls.	Boys.	Girls.
4–	41	38	—	1	—	—	7	8	32	28
5–	157	133	5	3	—	—	13	15	137	111
6–	141	170	5	6	2	3	8	15	124	141
7–	54	69	—	1	—	—	8	4	45	64
Total ..	393	410	11	10	2	3	36	42	338	344

Of these 800 infants, less than 5 per cent. had V.A. below $\frac{6}{9}$, and only 3·2 per cent. "bad vision," chiefly squinters with amblyopia. Ten had refraction of 5·0 dioptres or more, one high myopia, and one irregular cornea. The others had mainly hypermetropic astigmatism; in one case 6 dioptres difference in the two axes.

For younger children Dr. Lloyd Evans suggested the use of script test letters (*School Hygiene*, 1910. 215) to reduce the mental factor, as script writing is now so commonly taught. A young child may not be able to designate the letters, although he may be able to write them down. There is also a tendency to make guesses, and even subconsciously to learn from others. A diminishing, but still considerable, mental factor persists through the elementary stage.

The value $\frac{6}{6}$ is the standard, but it represents an undistributed zero and is exceeded by many. Kotelmann, one of the early scientific workers in school, examined members of wild races, finding cases with V.A. more than double this value. He notes three young Nubians had 2·67 and ten adults 2·56, with fifteen adult Kalmucks 2·88. Many of our children read $\frac{6}{4}$, a few $\frac{6}{3}$.

If all are to make efficient progress in school, there must be a general vision test applied. At present the vision of the youngest groups is not recorded. At the age of 8 ordinary school inspection shewed 37·9 per cent. boys and 34·6 per cent. girls—that is, about one-third with normal vision (London, 1917). This was the routine vision testing done by the school doctor. Fifteen years earlier, the oculists—trained ophthalmic surgeons—found nearly double this proportion, over 60 per cent. normal, and this being suspected too low, the enquiry noted on page 475 shewed that 81 per cent. boys and 72 per cent. girls at 8 years of age had normal vision, and Dr. M. Hogarth's careful enquiry raised this percentage still higher. Evidently on these results, with the testing done in routine medical inspection, up to 50 per cent. of the visually defective eight-year-old children have spurious defect of visual acuity due to psychical causes.

The routine testing of eyes is a novel experience to the child, and below the age of 10, whilst testing detects real visual defect, it also includes a large number without such defect. The necessity for accurate and costly methods which are so discounted is not evident. When results are put side by side for comparison, errors of experiment so enormous make any deductions of doubtful value, and the work is not worth the cost as a routine measure.

If the method already described as used in early years at Bradford is followed, by eliminating much of the psychical error, practically equal, if not superior, results ophthalmologically are obtained, and all the educationally defective vision is detected at one-tenth the

present cost. All the children can be tested annually, and not only two age groups. It was the outcome of actual school practice, and not evolved from text-books or adult out-patient experience. It has educational value, and directs to each child the personal attention of the teacher, who should correct the papers and make out lists of defectives. It also directs the child's attention to its own defect, and leads to children being advantageously placed in class.

Many children likely to feel strain later are missed by distant vision tests, as they can accommodate sufficiently for the time required for tests, although they may not be able to maintain this for long, and for near work may be scowling and frowning much of the time. Unless the school doctors are to extend their tests to include these, the work could be done just as well by the teachers or by school nurses, as indeed it often is and always should be in the first instance.

Testing near vision is rarely necessary in school. Print of various sizes is used. Diamond print should be read at half a metre. It was used by Jaeger, who suggested certain reading types, and as it was his smallest, it is often called J_1. Minion type is called J_4.

Recording the Vision.—The refraction of the eye, as shewn later, varies so enormously with age, especially in the cases requiring attention, that any classification without age and sex distinction may lead to error.

In a typical Report of a Medical Officer of Health the detailed analysis given in nine classes for each eye embraced 2000 children of 7 to 8, 700 of 10 to 11, and 200 of 13 or older ; the irregular age distribution making the percentages and other distinctions absolutely meaningless. For the same reason, most of the visual returns in the Reports of the Medical Officer of the Board of Education are vitiated.

Classifications of acuity should be by the Snellen fractions, and attempts to combine the vision of the two eyes into a scale results in absurdities. The only practical scale for school-work is based on binocular vision.

Normal, $\frac{6}{6}$. Fair, $\frac{6}{9}$ to $\frac{6}{12}$. Bad, $\frac{6}{18}$ or worse.

Where both eyes shew defect, visual acuity is as a rule a trifle higher with both, than with either singly.

The figures given in Table 70 were obtained for 7787 children, using both eyes, in the Bradford tests.

This is a record of one of the earliest ophthalmic tests carried out in English schools, and is also of interest as a third of the children got vision more acute than $\frac{6}{6}$; the details exceeding $\frac{6}{6}$ being seldom recorded. At the same time, from the quite different method used

these records are not strictly comparable with the usual vision testings, although control tests on the same children with test types gave strictly comparable results.

TABLE 70.

BINOCULAR VISION OF 8000 BRADFORD CHILDREN (1895).

Ages ..		7–	8–	9–	10–	11–	12–	13–	14–	Totals.	Per-centage.	
Normal.												
More than $\frac{6}{6}$	B.	76	152	265	375	287	263	81	11	1512	38·8	80·4 Boys
	G.	51	144	185	219	243	213	97	27	1186	30·0	
$\frac{6}{6}$	B.	148	285	299	309	270	234	67	8	1622	41·6	75·0 Girls
	G.	157	295	298	312	297	253	121	14	1753	45·0	
Defective.												
$\frac{6}{9}$	B.	49	74	79	88	67	57	19	2	435	11·1	19·6 Boys
	G.	80	107	112	98	78	66	28	4	577	15·0	
$\frac{6}{12}$ or less	B.	28	64	55	55	68	44	14	1	330	8·5	25·0 Girls
	G.	32	60	75	74	51	60	18	2	372	10·0	

These Bradford tests may be compared with a table in the *Brighton Report* for 1913, as to general results from 6000 to 7000 cases each year.

TABLE 71.

Brighton ..		1909.	1910.	1911.	1912.	1913.	Bradford, 1895.
$\frac{6}{6}$ or $\frac{6}{9}$	Boys	90·8	91·7	88·8	90·9	93·5	91·5
	Girls	89·1	88·3	85·3	88·3	91·9	90·0
$\frac{6}{12}$	Boys	3·2	3·5	6·0	4·5	3·6	B. 8·5 G. 10·0
	Girls	4·1	5·6	8·1	6·8	4·7	
$\frac{6}{18}$ or less	Boys	6·0	4·8	5·1	4·6	2·9	
	Girls	6·8	6·0	6·6	4·9	3·4	

From this it appears that the school lesson method is as effective in selection as the detailed ophthalmic test, and it certainly is cheaper and more educational.

Whilst the Bradford method gives the visual efficiency in daily school life, it has obvious defects: (1) There is no provision for the vision of each eye being determined; (2) there is no provision against ciliary action compensating defects; (3) it does not help in analysing the defects; (4) copying.

Dr. Andrew Little (*Journ. Roy. San. Inst.*, 1903. 816) tested the

method by further subjecting the children with $\frac{6}{6}$ normal vision to the test, after instilling homatropine into each eye. His results are of interest, as this reveals all the hypermetropia and hypermetropic astigmatism concealed by accommodation compensation. He gives full figures, but they may be summed as percentage reading $\frac{6}{6}$ with both eyes together 69·5; with each eye separately it was 60·4, and after instilling homatropine, this fell to 31·3 per cent., which number may be taken as representing emmetropes, all the others having some form of hypermetropia.

Right and Left Eyes.—One eye is mainly used in fixation, the other is accessory. Rosenbach's test demonstrates this. Two objects, one near and the other distant, are looked at with both eyes. Suppose an index finger held up at arm's length to cover a chimney or spire some hundred yards away; strictly speaking, one of the objects should be seen doubled, but unless attention is specially directed to it, or lighting brilliant, its image is neglected or suppressed in one eye, and only the overlapping images fixed by the other eye are attended to. On closing the left eye, no apparent change occurs in most right-handed people. If now the left eye is opened and the right eye closed, the finger, instead of covering the chimney or spire, appears to have jumped many degrees to the right. The right eye having been used in the fixation of both objects, the left only as an accessory, causes this left to need readjustment for distant fixation, and the image of the finger appears displaced relatively to the chimney.

Sudden loss of vision in one eye is occasionally alleged in school children. The loss may either be complete, or may mean reduction of visual acuity to about fingers at one yard. This may arise from the first discovery of an amblyopic eye. In one case the writer unexpectedly found in a doctor himself a congenital cataractous condition, as a three-rayed star, probably from birth. Several times some little injury or knock has, by suggestion, developed a functional condition, as when tested with red and green glasses and types, binocular vision was present.

Each of these last cases was relieved by hypnoidal suggestion in the dark room. Another class of case which the writer has come across in about a dozen instances in school children is the sudden blocking of a branch of the central artery of the retina. In recent cases the retinal picture is characteristic, great œdema round the macula, with perhaps a twig between the disc and macula escaping, or vice versa, followed by atrophy later. All the children were girls with gross valvular disease, in some unsuspected till the eye directed attention to this. In adults, renal disease is common in these cases, but no renal case occurred amongst these children.

In the usual vision testing, whether right or left eyes appear

most defective seems almost a matter of which is tested first. Some figures from the *Board of Education Report*, 1911. 38, may be quoted as also bearing on visual acuity.

Table 72.

District.	Numbers.	Eye.	$\frac{6}{6}$.	$\frac{6}{9}$.	$\frac{6}{12}$.	$\frac{6}{18}$.	$\frac{6}{24}$.	$\frac{6}{36}$.	$\frac{6}{60}$.
Tynemouth ..	1694	R.	89·1	5·5	1·5	1·9	0·6	0·8	0·6
		L.	66·9	23·9	4·1	3·2	0·5	0·8	0·6
Doncaster ..	1224	R.	41·6	41·4	8·3	8·7	—	—	—
		L.	40·4	42·1	8·4	9·1	—	—	—
Blackburn ..	3918	R.	30·6	39·3	13·7	5·7	4·8	4·1	1·8
		L.	28·3	39·3	14·3	6·3	5·0	4·4	2·4

These extraordinary results call for explanation, but there appears to have been no further enquiry published. So, too, for bad vision taken as $\frac{6}{18}$ or worse, there are variations from 19·5 per cent. in Newcastle to 4·4 per cent. in Ashton-under-Lyne, and 11·3 per cent. in Lancashire, over 12 per cent. in Middlesex, down to 4·8 in Gloucestershire, and below 4 per cent. in West Sussex.

Since 1914 these tables have been discontinued, but tables are

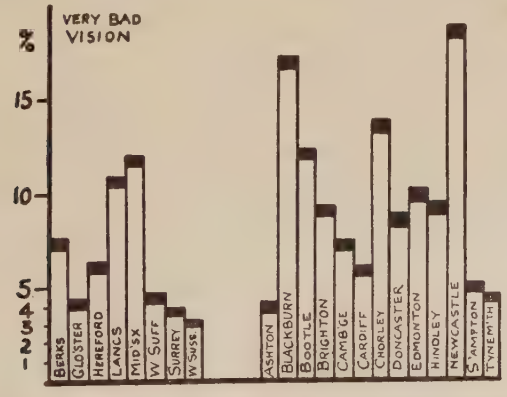


Fig. 98.—PERCENTAGE OF VERY BAD VISION RECORDED IN DIFFERENT DISTRICTS.

still given for defective vision (undefined) varying from 10·7 in the best, to 59·6 in the worst districts.

The testing of visual acuity so carried out in the routine inspections is unreliable and valueless for any close scientific study; very rough as a means of selecting defective cases, and too costly for practical purposes and general application. In Fig. 99 the

stippled area represents the minimum amount of the error at each age in London school examinations, and this is seen to be 25 to 30 per cent. at 8 years old.

A good standard record for comparing R. and L. can be

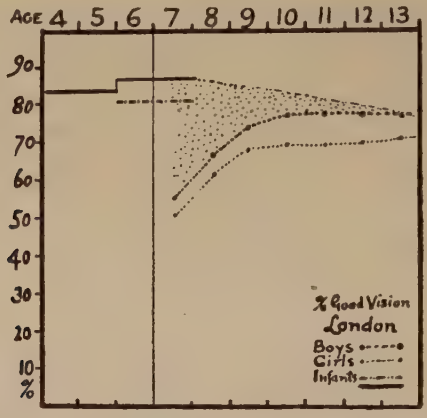


FIG. 99.—PERCENTAGE OF NORMAL VISION.

The dotted area gives the minimum error at various ages from other than visual factors.

obtained from the last Report of Govan, 1919, where ophthalmic work was supervised by Inglis Pollock. The records are given of 7924 eyes. There should have been an age distribution for final records.

TABLE 73.

GOVAN VISION. (INGLIS POLLOCK.)

	Good.	Fair.		Bad Vision.				
	$\frac{6}{6}$.	$\frac{6}{9}$.	$\frac{6}{12}$.	$\frac{6}{18}$.	$\frac{6}{24}$.	$\frac{6}{36}$.	$\frac{6}{60}$.	0.
Right—								
Boys	1545	185	107	66	28	29	18	1
Girls	1426	235	129	89	47	33	22	2
Children	2971	420	236	155	75	62	40	3
Left—								
Boys	1456	229	134	73	33	29	22	3
Girls	1368	262	147	85	48	32	38	3
Children	2824	491	281	158	81	61	60	6

When the working vision of the same children was taken depending on their best eye, the results were—

TABLE 74.
GOVAN, 1919.

	Practical Visual Acuity (Both Eyes Used).						
	Good.	Per Cent.	Fair.	Per Cent.	Bad.	Per Cent.	Blind.
Boys	3001	*75·8*	655	*16·5*	298	*7·5*	4
Girls	2794	*70·4*	773	*19·4*	394	*9·9*	5
Total	5795	*73·1*	1428	*18·0*	692	*8·7*	9

Colour Vision.—Colour vision is rarely tested. Mere naming of colours should be avoided. Colour discrimination is possibly acquired late in the second year, but power of naming colours only comes one or two years later, and is delayed in dull children (Warburg, *Munch. Med. Woch.*, 1909. 49).

For school purposes the comparison of wools is a rough approximation. If amidst a good variety the pale pinks and pale greens can be correctly matched, that will probably be sufficient. The red-green confusion variety is commonest and most important.

The young child remains dumb if shewn an object and asked, "What colour is that?" Whereas it will often reply sharply if asked, "What does this look like?" avoiding the term "colour."

Edridge Green has devised some cards with blotches of colours which make up letters against their confusion colour in the background. They are useful and portable, and more accurate than the wools. For careful work, the dark room with coloured lights is most satisfactory.

The colour lamp used by Edridge Green is a safe method for testing candidates for naval work, or boy artificerships, as wools pass about 50 per cent. unsafe industrially, whilst of those rejected a considerable number are quite safe according to Green.

About 4 per cent. of boys, and one-tenth of that proportion of girls, shew obvious colour defect; but the numbers depend entirely on the definition of colour defect. It appears sex linked (Fig. 3). G. L. Collins (*U.S. Public Health Bull.*, 92. 1918. 29) states that, in everyday life among healthy persons in the United States, colour-blindness, excluding pentachromic, occurs in about 8·6 per cent. of men, and 2·2 per cent. of women. Colour-blindness, dangerous in occupations requiring recognition of signal light, occurs in about 3·1 per cent. of American men and 0·7 per cent. of women. The possession of the sense of yellow, according to Green, practically defines an individual who is industrially safe.

Dr. G. H. Taylor of Sydney has drawn attention to the colour-blind person during examination as adopting a listening expression,

whilst the colour efficient has a watching expression. He also thinks the colour-blind have inflections in the voice, without any warmth, but stammering is less common amongst them than in visually normal people (*Med. J. of Aus.*, 1924. i. 313).

One must remember that what a person learns to call red may differ in different people.

It is extraordinary how often a colour-blind lad is met possibly confusing scarlet and bright green, and unaware of any defect. The writer recently saw a candidate for an Art scholarship still unaware of his marked defect, and as he had excellent form sense, a *tour de crayon* that could produce a portrait, he was recommended for the scholarship. Lord Rayleigh described (*Nature*, 1881. 65) a very delicate matching test whereby he detected slight red and green anomalies, but this is not important for scholars.

One of the most extensive enquiries by B. J. Jeffries in Boston (*School Document*, No. 13. 1880) found 4·04 per cent. colour-blind among 14,469 boys, and 0·066 per cent. of 13,458 girls. Mary Collins (*Colour-Blindness*, Kegan Paul, 1925) has investigated a number of red-green blind. She found Edridge Green's lamp the most trustworthy, and Holmgren's wools reliable.

Colour-Blindness in Teachers.—Sometimes the colour scotoma of tobacco amblyopia gives rise to trouble in teachers, who may complain of quality of red ink, as they cannot see it in written figures, or bright metal objects are not seen well in detail. Faces may appear washed out and indistinct, or print may not be easily read even with glasses. Formerly they would say that a half-sovereign looked like sixpence.

There is generally a history of excessive smoking, over three ounces of heavy dark tobacco weekly, and possibly some malaise from stomach or other trouble. There was surprisingly little during the War. Testing for colour by setting them to pick out red or green beads in a saucer usually catches these cases. Two pins, the head of one dipped in red sealing-wax, the other in green, are useful test objects. The test is more delicate when only using one eye—the colour-blind fails to name the colour. Improvement rapidly follows the abandonment or severe restriction of tobacco, where this alone is the cause. The youngest man the author has met with this defect was 27.

Visual Defect.—Failure in good visual acuity may be due to many causes. If vision becomes better on looking through a pinhole in a thin black disc, the cause of poor vision is due to some error of refraction of the eye. If there is no improvement by using the stenopaic disc (pinhole) some defect in the media of the eye itself is suspected. This may be corneal haziness or opacity, opacities in the lens of varying degrees (cataract), or retinal troubles, of which the commonest is disseminated choroiditis.

To detect corneal defect the eye should be inspected by light on it sideways, focussed on the cornea with a 2-in. convex lens of 13 D.; any haze or opacity will then shew up. To examine the lens or deeper media and retina, the child must be seen in the dark room, and except for experienced workers the pupils should be fully dilated. This is done by using a small lamella of gelatine containing homatropine and cocaine, one being placed in each conjunctival sac twenty to thirty minutes before examination. A drop of castor-oil solution with 2 per cent. cocaine and 1 per cent. homatropine is equally effective. After the examination a drop of castor oil solution of 1 per cent. eserine will neutralize the mydriatic effect in a short time.

The indirect method is the best to begin with. The child is seated in the dark room with the light a little to one side and behind it. The observer sits in front of the child, and from an arm's length, with a concave mirror of about 20 to 25 cm. focus having a small hole in the centre, he throws the light on the eye. A double convex field lens about 5 or 6 cm. in diameter and of 13 D. strength is held closely in front of the eye to be examined. Directing the child to look at the observer's opposite ear, on looking through the central opening of the mirror the optic disc should be seen as a white spot with vessels radiating from it.

Further details of the method of examination must be sought in text-books, but only practice and patience will give the observer confidence in his own powers. Skill will be rapidly acquired if for the first few months homatropine is used, so that a well-dilated pupil is secured. As soon as the indirect method has been used a little, the direct method may be begun, and for this an electric ophthalmoscope is incomparably the handiest.

Every competent school doctor should be able to examine the optic disc and detect any inflammation of the nerve head, optic neuritis being of importance in many obscure childish conditions. He should be able to examine the macula, and to recognize even such a rare condition as embolism of the central artery, more common than is usually believed. Disseminated choroiditis he can hardly miss, but the rarer retinitis pigmentosa is not likely to be seen unless carefully looked for. The conditions of the normal fundus are so varied that much experience and constant reference to an ophthalmic atlas will be advisable at first. More is learned by making a few monochrome drawings, as accurate to life as possible, than by reading many books. Gower's *Ophthalmoscopy* is an extremely useful work from this point of view.

The Refraction of the Eye.—The property of bending the rays of light diverging from objects, so that they converge to form an image is described as the refractive power of the eye, and the measure of this power is shortly called refraction of the eye. In the normal

eye at rest, rays coming from any distance over 6 m. may be regarded as parallel. They fall on the convex cornea which refracts them towards the axis.

This refractive effect is added to by action of the lens and the vitreous, so that the rays converge to form an image on the macula about 23 mm. behind the corneal surface. With ordinary light made up of varying wave-lengths, which constitute the different colours of the spectrum from red to violet, the violet rays are more bent then the rest of the spectrum, and the red rays least.

What is called chromatic aberration takes place, but is not noticeable unless special precautions are taken.

Squint.—The hand and eye mechanism to which human supremacy is due is dependent on associated movements of the two eyes giving stereoscopic vision. The greatest part of these movements is convergence, relatively linked up in close association with accommodation of the lens.

In the young child, the inherited association of these functions of convergence and accommodation is strained by near work, as shortness of the undeveloped eye requires compensation by accommodation beyond that involved in nearness of work. The result is an excessive amount of convergence proportioned to this accommodation.

All babies and infants squint at times if they attempt near work—threading beads, for instance. Time remedies this with the growth of the eyeball to nearly its mature size by the age of 7, and this functional part of squinting should by then disappear. It may, however, have upset the nervous balance, and remain as a habit, or one eye may be comparatively defective, and effort at correct convergence remain undeveloped. In a boy of 10, recently seen, one eye was emmetropic with normal vision, the other hypermetropic to the extent of 5 dioptres; but as no effort at convergence was made, correction by glasses was held to be waste of time.

This is a superficial account of the commonest variety of squint where the most defective eye turns too much inwards.

Often that eye has amblyopia—that is, poor vision, $\frac{6}{24}$ or less.

As a rule, an amblyopic eye is out of gear when first seen and the squint may persist. There being no formal inspection of vision in school entrants, it is probable that many cases of squint are not noticed at the only period when treatment is likely to be of any visual use, if indeed it is not then almost too late.

Many cases of hypermetropia are met in school-days with one eye normal, the other amblyopic, and although there is now no evidence of squint, the history of earlier squinting by the defective eye is common.

The development of co-ordination of the eyes usually goes on earlier than appreciation of speech, and Nature's cure should be

early. From the time the macula develops, about the third month, squinting movements should diminish. Outward squint or squint where convergence seems the disability, often suggests development trouble, which again is frequently associated with mental defect.

There are rarer forms of squinting, and in 3 or 4 per cent. of the squinters of school age a divergent strabismus occurs, practically always associated with myopia. As a rule squint is obvious, but noticeable squint seems rarer than it was twenty years ago. On holding up a finger and directing the child to look at it, the squinting eye shews up. If a card be interposed between the finger and fixing eye—unless very amblyopic—the squinter now jumps back to fix the object. Squint of finer degrees can be estimated in the dark room by observing the position of the image of the retinoscopy mirror in regard to the pupil of the eye when the patient looks at the hole in the mirror. It should be practically central, but in the squinting eye the image will be markedly to the outer side of the pupil if there is an internal squint, the reverse with external, and above or below with other varieties.

So far as the doctor is concerned, squint should be eliminated in the nursery-school age, either by nature or by his skill. The refraction of both eyes must be determined and the eyes brought as near equality as possible by full correcting glasses always to be worn, even after operation. The use of atropine for a time makes them necessary, and prevents them being prematurely discarded. In earliest infancy the child may be made to use the handicapped squinting eye by covering the good eye many hours a day and keeping its accommodation paralysed with atropine, watch being maintained to see that this eye does not in turn take on the squinting habit.

By the use of a variable stereoscope, attempts can be made in the younger children to develop the fusion faculty. Indeed, in the nursery school, such a variable stereoscope would be a useful adjunct in the education of all the children. As a popular remedy for squint it is not likely to be a success.

For most who squint, apart from near work, if binocular vision is to be obtained, the quickest way is to operate as soon as the definite correcting glasses have been worn a short time. There is no advantage in delaying operation where the squint is definitely in one eye, as it will be likely to get amblyopic. In any case, for good functional result, operation must be before the days of near work in school are reached. After that stage, operation is still advised, if only for appearance' sake. Orthoptic treatment by fusion training and other such means requires persistence, and gives results that for ordinary school work need not be considered.

The squint operation appears simple, but is a highly technical

proceeding, not only of tenotomy of the internal rectus, but also of the advancement of the external. It requires considerable experience to feel safe in the result, and occasionally further operation is necessary.

Measurement of Accommodation.—The ideal form of the eye is that, where with accommodation at rest, parallel rays from a distant object are clearly focussed on the retina. With such an emmetropic eye, when any near object is looked at, an effort of accommodation is made, the lens becomes more convex, and exerts a greater refractive effect. This causes the rays which diverge from near objects to be more bent, so that they are still focussed on the retina.

The amount of increase in the refractive power is measured by the lens which would be equivalent to it. If an object is a metre off, then a lens of one metre focal length—that is, 1 D. refractive power—will cause the divergent rays to become parallel, and if the eye observes the object through this lens, the parallel rays are focussed on the retina without any accommodation. If the lens is taken away, then accommodation equal to the lens power, or 1 D., has to be exerted. If the object is half a metre off, it will require a refractive power of 2 D.; at a quarter metre this becomes 4 D. The increase in the accommodation required rapidly increases the nearer the object, and convergence of the two eyes is also proportionate, so that for nearness of the object or work the muscular strain may become very great.

The ciliary muscle is very susceptible of fatigue, and Baur (*Inter. Arch. f. Schulhyg.*, 1911. 52) has based a method of measuring fatigue on this. Its value, however, is doubtful for other than optical reasons.

The accommodation possible by the greatest effort, and then only for a matter of seconds rather than minutes, in an emmetropic eye, averages about 14 D. at the age of 10; about 12 D. at 15; and about 10 D. at 20. Only half or a third of this is available for continuous work, as the eye muscles cannot maintain the strain of the full amount very long. If there is added to that another dioptre, on account of the child's eye not being completely grown, it may be safely taken that the healthy ten-year-old cannot continuously exert more accommodation than 5 D. to 6 D., and 1 D. of this has to be allowed for slight developmental shortening of the eye, so that 4 D. to 5 D. corresponds to the available accommodation for the nearest position for comfortable work in the normal ten-year-old. This accommodation gives a near point of $\frac{100}{4}$ to $\frac{100}{5}$, or 25 cm. to 20 cm., anything nearer being risky from the visual strain (Fig. 100).

With older persons at, say, twenty years, where the accommodation range has fallen to 10 D., the range for comfortable work is

a trifle less than half this, but no allowance now need be made for shortening of the eyeball, so the effective working accommodation may be taken as $\frac{100}{5}$ or 20 cm.

Measurement of Refraction.—The only safe way to examine refraction is to eliminate the variable dynamic factor of accommodation by paralysing the ciliary muscle with a mydriatic. Except

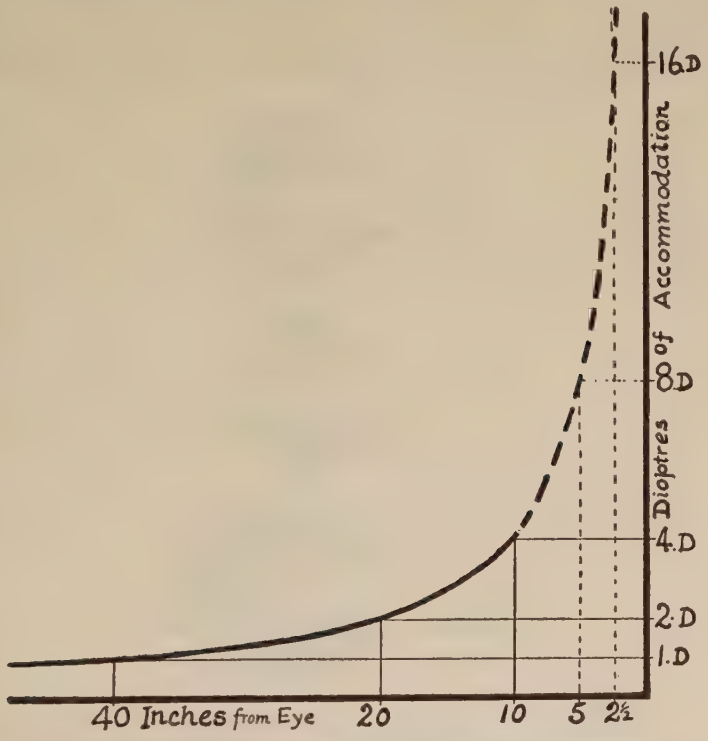


FIG. 100.—TO ILLUSTRATE THE GREAT INCREASE IN ACCOMMODATION REQUIRED, AS THE OBJECT GETS NEARER THE EYE.

Within the range dotted the amount exerted is harmful.

in rare instances, atropine need not be used for school purposes, as its action is too prolonged. It is frequently used, but unnecessarily. In 99 per cent. of the cases, homatropine and cocaine, a single drop of 2 per cent. solution three times at ten minute intervals, is the ideal mydriatic for school use. It is free from occasional intolerance shewn to atropine, where œdema and swelling occur.

Accommodation being almost completely paralysed in an emmetropic eye, incident rays will be exactly focussed on the retina. With infantile eyes not fully developed, and in many persons where the development has not gone on to full extent, the ocular axis is less than 23 mm., and sufficient refracting power is wanting to focus parallel rays on the retina; they therefore focus behind the retina. In a few children and many adults the eyeball has stretched

so that the retina may be 24, 25 or more millimetres behind the cornea, the axis being prolonged, corresponding parallel rays focus in front of the retina.

These conditions are represented by Fig. 101.

Formerly, the farthest distance at which a small object could be seen clearly was referred to as the *punctum remotum*. With hypermetropic or emmetropic eyes this was infinitely distant, but with myopes, it was a measure of the amount of myopia.

The nearest point which could be clearly seen, *punctum proximum*,

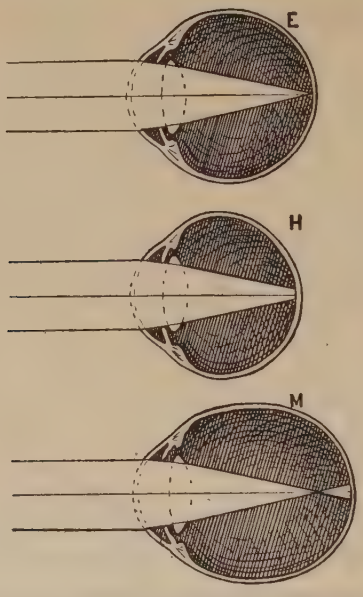


FIG. 101.—REFRACTIVE CONDITIONS, AND THE FAILURE TO FOCUS ACCURATELY ON THE RETINA, WITHOUT ACCOMMODATION.

indicated refraction together with maximum accommodative power of the lens. It would be far off in hypermetropia and very near in myopia, until the loss of elasticity in the lens by age tended to bring these points together.

On these conditions depend the measurement and treatment of refractive conditions of the eye. Light which passes along a path in one direction follows the same path if reversed. If parallel rays are converged by the eye to the retina, then rays diverging from the retina are parallel when they emerge from the eye.

This explains why the retina cannot be seen by merely looking into the eye, and why the pupillary space appears black. The observer's head gets into the way of the light entering and cuts it off, so that there is none to emerge in that direction. In the human being, the nerves in the retina are transparent, but in a

cat they are medullated and cause a good deal of irregular reflection, so that some rays emerge, and if with a good light behind one, a cat is seen in a dark corner, its eyes appear to gleam with the light.

To illuminate the interior of the eye and see it, light has to be thrown in the same direction as the observer looks. This was done by Helmholtz by using a small oblique mirror, and looking through a tiny hole scraped in the middle of the silvering. This is the principle of the ophthalmoscope. If the eye observed was emmetropic, the light thrown into it illuminated the retina and then passed back diverging from the retina, and issuing from the cornea as parallel rays, which fell on the mirror, passed through the small hole and could be focussed by the observer's eye to a picture of the observed retina.

If the eye seen was one with a short axis, underdeveloped and hypermetropic, then the retinal rays issuing from it would be divergent, and a convex lens required to make them parallel enough to form a picture in the observer's eye. The strength of this convex lens in dioptres, measures the amount of hypermetropia in dioptres.

With the long myopic eye, the rays from the retina are converging as they leave the corneal surfaces. To get a clear image a concave lens is needed of sufficient strength to make them parallel. The strength of this lens gives the measure of the myopia.

In Morton's and other good ophthalmoscopes, a set of these lenses, both concave and convex, is mounted in an endless band, and can be rotated behind the little mirror of the ophthalmoscope.

This measurement of the refraction by interposition of lenses is known as the direct method. It appears simple, but is only safe in experienced hands, as the worker has to learn to relax his own accommodation, or he may make wrong estimates as to the lens strength needed; it is, therefore, not recommended for any but most expert workers.

Another method would be by having the patient with paralysed accommodation read distant test types. The emmetrope could do this, but the myope would require a concave, and the hypertrope a convex lens, to make the parallel rays diverge or converge sufficiently to be focussed on the retina. Here again the focal strength of lens gives the measure of refraction in dioptres.

The various lenses used in ophthalmic work require actual handling to gain a ready acquaintance with their use. Fig. 102 shows sections and illustrations of different simple lenses. They may be combined in various ways and sometimes it is not easy to be quite sure of the strength of a lens which a patient is wearing.

Retinoscopy and the Shadow Test.—In practice, reading of types depends on the patient's judgment, but with children it is better to judge for oneself, so an objective method is used. It is known as skiascopy, or the shadow test.

A concave ophthalmic mirror of about 25 to 30 cm. focus is used to throw light into the eye at a distance of about a metre. On rotating it a little about a transverse axis, the shadow of the edge of the iris, or edge of the spot of light, thrown on the retina, is seen to move across the pupil as a black band or spot. If it cannot be judged which way it moves, the eye is approximately emmetropic, or at least not more than 1 D. myopic. This 1 D. has to be allowed as the distance from which the eye is being observed.

If the eye is hypermetropic, the shadow in the pupil moves

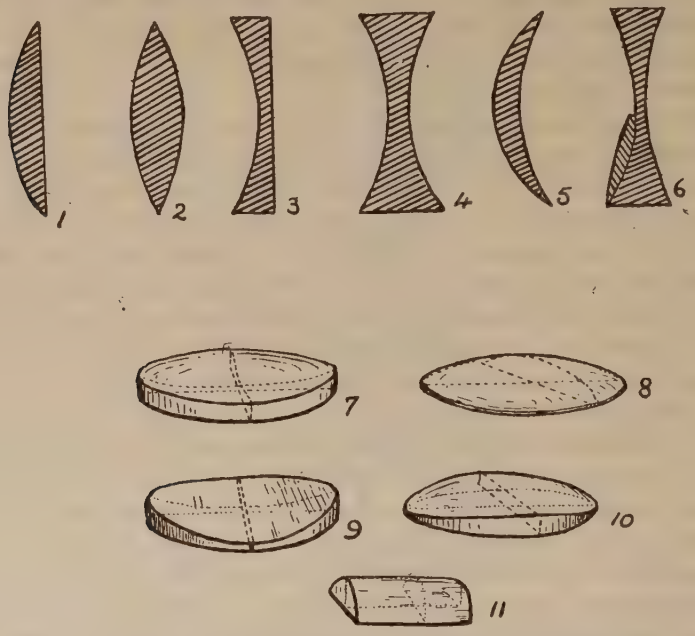


FIG. 102.—THE VARIOUS TYPES OF LENSES.

1, Plano-convex; 2, bi-convex; 3, plano-concave; 4, bi-concave; 5, concavo-convex or periscopic; 6, bi-focal; 7 and 8, plano-spherical; 9, 10, and 11, cylindrical.

against the direction in which the concave mirror is rotated—that is, contrary to the spot of light on the face.

A convex lens is placed in front of the patient's eye, in a trial frame, and the movement again watched. The strength of this convex lens is gradually increased until the movement of the shadow is reversed, and it is now moving with the mirror, and with the spot of light on the face. When this has been attained, the convex lens used has corrected all the hypermetropia, and set up myopia of 1 D.; so now if, say, there is + 7 D. in the trial frame, — 1 D. is added, and the static refraction found as + 6 D.

Similarly, if on first looking at the eye the movement of the shadow is with the mirror and with the light on the face the eye is myopic, and gradually increasing concave lenses are used till the

direction of the shadow is reversed, and it is against the mirror. The myopia is now all corrected by the lens except the 1 D. for the metre distance, so we add — 1 D. to the result, and if the lens in the frame is — 7 D. the static refraction is found as — 8 D.

Nothing but practice gives familiarity and accuracy in using this method. Many experienced surgeons use a plane mirror, as the feebler light gives more accurate work. The movements of the shadow are the reverse of those with the concave mirror.

The beginner and the amateur are advised to use the concave mirror till they are expert enough to make their own choice. Many observers manage to measure the refraction of the eye without using a mydriatic, by directing the child to look at a distant light; or, as A. R. Galloway (*School Hygiene*, 1919) advises, to read distant test types whilst the doctor measures the refraction directly, by finding what lens focusses the retina clearly, as in the first method described above. This examination, without a mydriatic, necessitates the observer relaxing his own accommodation. It is rarely entirely trustworthy, as spasm of the child's accommodation may exist and lead to incorrect values. In any case, it is only suited to a well-trained and very expert worker, and is not here recommended.

Astigmatism.—For simplicity, the short eye of the hypermetropic (H), the emmetrope (E), and the long eye of the myopic (M), have been supposed to be regularly spheroidal in the shape of the retina, so that a vertical section at right angles to the axis would form a circle; sometimes, from irregular growth, the cornea departs from this. The curvature is greatest in one direction and least at right angles to this. Most often the direction nearest the vertical is greatest. This is called "astigmatism according to rule."

An eye measured in one plane passing through its axis might appear emmetropic, and in another plane at right angles to this one and also passing through the visual axis, it might appear either hypermetropic or myopic. This is the condition called simple astigmatism (As). There may, however, be any combination of myopia or hypermetropia with astigmatism. If the eye in both directions is myopic but in different amounts, there is myopic astigmatism; if hypermetropic in different degrees, there is hypermetropic astigmatism. If one direction is myopic and the other hypermetropic, this is mixed astigmatism.

The term astigmatism was invented by Whewell as indicating that a point of light is not focussed to a point, but irregularly, in the two directions corresponding to the axes of greatest and least refraction. All eyes are a trifle astigmatic in various directions, and this fact accounts for the stars not being seen as the points of light, which they are, but as rayed figures.

In examining an eye by retinoscopy, the shadow often tends to move in one axis, and when reversed in this axis, is still found unreversed in the direction at right angles. There is then a condition of astigmatism.

Suppose that the shadow in a right eye appears to move against the light in a direction down and out, and that it is reversed by + 3·5 D., after correcting this by the addition of — 1 D. already described, the refraction in that direction is noted as + 2·5 D. Down and in, the shadow may still move against the light, and not be reversed till + 5 D. is reached.

The refraction, then, in this direction is + 4 D., as noted. This represents hypermetropic astigmatism. Another eye, the left, by similar proceeding might be found emmetropic horizontally, but myopic vertically, a case of simple myopic astigmatism.

By using a cylinder, that is a glass which is ground, curved only in one direction, either convex or concave as the case may be,

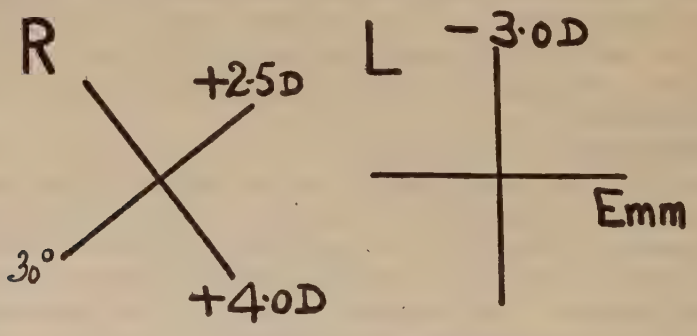


Fig. 103.—RECORD OF RETINOSCOPY.

corresponding to the difference between the two axes, the correction for astigmatism is obtained.

In the case of the right above, it would be a convex cylinder of + 1·5 D. with the axis down and out at 30°. The eye with this correction would then be equivalent to a hypermetropic eye of + 2·5 D., and if a young child, with plenty of accommodation, might need no further correction, and possibly it could get along without this.

In the case of the left eye above, the correction would be a concave cylinder — 3 D. with its axis horizontal. The eye ought then to be practically emmetropic.

Astigmatism being practically all due to unequal curvature of the cornea, it may be measured by the astigmometer which measures the distances between images reflected from the cornea, these distances varying with the curvature of the diameter along which they are measured. The instrument, however, is not portable,

and is more useful in hospital than in school. Barrington and K. Pearson, in the *Eugenics Laboratory Memoirs*, No. V, 1909, quote the distribution of astigmatism in 3170 Berne children.

TABLE 75.

DISTRIBUTION OF ASTIGMATISM IN 3170 BERNE CHILDREN.

Dioptres ..	−0·5.	−0·25.	0.	0·25.	0·5.	0·75.	1·0.	1·25.	1·75.	2·625	3·5.	Total.
Secondary—												
Boys, 11–16..	—	7	51	100	275	238	97	65	26	15	8	882
Primary—												
Boys, 9–15 ..	4	8	39	94	153	175	67	38	29	9	4	620
Secondary—												
Girls, 12–16 ..	—	14	43	79	264	310	108	85	90	22	19	1034
Primary—												
Girls, 9–15 ..	1	4	32	60	125	206	82	60	44	10	10	634

For the general child population of Berne we may take the corneal astigmatism—

Boys 0·705 D. σ 0·525. Coefficient of variation 74·5.
Girls 0·839 D. σ 0·595. Coefficient of variation 70·9.

"Against the rule" in reference to astigmatism means when the most curved axis is nearest the horizontal. In the above table it is represented by the minus sign.

Results adapted from Steiger (*Zeit. f. Augenheil.*, Bd. XVI, S. 236) shew a regular but sensible decrease of astigmatism from 10 years of age to the end of life. Rheinstein (*Zeit. f. S.*, 1892. 488) gives the result of repeated examinations on the same children at six years' intervals, in percentages—

First examination	54·5 H.	9·85 M.	35·6 E.
Final examination	14·27 H.	37·4 M.	48·3 E.

The H varied in the first examination from 75 per cent. to 50 per cent. between bottom and top classes. The M from zero to 22 per cent.

He determined the averages for each class and found that in Mannheim the refraction normally altered 0·2 D. per annum, any amount over this being abnormal. This whole subject needs exploration with a view to early detection of potential myopes.

Asthenopia, meaning weakness of vision, is a functional condition more common in early adult life than among children. Various irritative conditions of the lids or conjunctiva may be present in slight degree, or difficulty in seeing in poor light. There may, however, be none of these, but a neurotic girl or boy who sees the test type clearly after working a short time sees things blurred,

the eyes ache, and there is a sense of effort or even headache. Migraine may be also a frequent occurrence. As a rule, there is a little hypermetropia or slight astigmatism, but nothing very much wrong. Careful testing generally shews diminished amplitude of accommodation.

Sometimes the balance of the two eyes is not maintained with the axes parallel when at rest. There may be a slight variation in their level horizontally, one tending to turn a little above the horizontal plane, it may be only a degree or two. In young adults this condition of hyperphoria may cause much trouble, and sometimes is difficult to detect or measure.

Commoner conditions are where there is a tendency to turn in (esophoria) or out (exophoria), constituting a latent squint. The continuous effort of keeping the axes adjusted may set up various kinds of nerve tension. The use of prisms or decentring of lenses may be useful in such cases, but are highly technical proceedings very rarely required with children. As a rule, myopic spectacles are more comfortable if the centres of the lenses are a trifle wide, whereas hypermetropic are better with closely centred lenses.

These details need much experience for their application, and are beyond the ordinary work of the school doctor.

Emmetropia of the Normal Eye.—The functional efficiency of the eye varies with age. When adult life is reached, the emmetropic eye is the ideal condition. As a child under 10 years of age the emmetrope, still having an immature eye, was hypermetropic to one or two dioptres, and had to use additional accommodation to see near things, but there was plenty of accommodation to do all that was wanted. In its earliest school years the child probably bored down over its work, holding it within five or six inches of the eye, or even squinted at work, but came to no harm. As time goes on the lens loses its elasticity. By 40 or 50 years of age it is unable to maintain sufficient accommodation to read with comfort. The eyes may begin to feel sticky, or when reading the print may become indistinct, the letters run together. Some help is needed now. The person is becoming presbyopic and should wear convex reading glasses for near work. The strength will increase about a dioptre for every five years after 40 to 45.

Teachers are well advised not to postpone to the latest possible time the use of working glasses.

Hypermetropia.—With people who are not likely to be emmetropic there is considerable hypermetropia in childhood, probably 3 D. or more, and corresponding difficulty in seeing near objects as there has to be a great increase in accommodative power. Such a child presents manifest hypermetropia (*m* H). If it reads $\frac{6}{6}$, it can still do so with convex lenses in front of the eye, and the strongest lens

it will take and still see clearly represents the manifest hypermetropia. Under a mydriatic there will be more latent (H L) still, the sum of manifest and latent representing the total hypermetropia. Some of these children in earlier years present convergent squint, which persists in a proportion unless treated, and often the vision of one eye, generally the left, is extremely defective; it is amblyopic, and as they grow up, acuity may only be $\frac{6}{24}$ or less. When in addition there is some astigmatism all the conditions are aggravated, as one sector of the iris may be strained to compensate for this. The strain may not shew until the power of accommodation is beginning to be considerably reduced, after the age of 10 or 11.

Hypermetropia is never merely a school product. It is racial or familial, and some writers think that rickets conduces to the want of development. The visual acuity for distance is often hyperacute, so that strain may exist and is frequently unsuspected. When headache or other nervous signs—frowning, twitching of facial muscles, blinking, and so on—occur, there is also a general nervous disposition as well. These children suffer more when fatigued or out of health. A holiday gives relief not only by reducing eye-work, but also by its general tonic effect on the health.

The elementary school child rarely suffers much from (H) or (H As). As a rule, the troubles of headaches, giddiness, inability to work continuously, or sleeplessness begin to be evident, and are not common until in the secondary school.

During college life, symptoms are likely to become more evident, as various cranial sensations, or dull aching over the best eye. The treatment is the wearing of proper correcting glasses. Sometimes, too, rest for the eyes is necessary, by keeping them under atropine for several weeks, and continuing with the glasses.

The safe rule for glasses in hypermetropia is to wear the *strongest convex* glasses which can be borne comfortably with good vision.

Myopia.—The optical condition of myopia is due to lengthening of the axis of the eye. Each 3 D. of myopia roughly means a millimetre of lengthening. Children are not born myopic, but in many cases the tissues of the eye yield and hypermetropia (generally with astigmatism) passes through emmetropia to myopia. Whilst in the young child the hypermetropic eye does not tend to get worse but may improve, with myopia all alteration is for the worse optically.

The cause of myopia is still unknown. There is a rare variety which seems almost congenital. Children on entrance to school are found already with considerable degrees, and they are likely to get worse, but in some rare cases it remains unaltered.

A typical case is G. W.: Glasses prescribed when 6 years old, — 6·0 D. spherical, with — 0·75 D. cyl.; never needed altering

although she is now 17½. In her case the stationary myopia was probably congenital. Another case of a man teacher aged 24, normal vision with Rt. = — 6·0 D., sph. L. = — 0·25 D., sph. The same glasses worn for ten years. This class of case is a very uncommon one.

There is another large class of myopes, who appear in the later days of school-life ; and whilst some may go on to visual inefficiency, the majority do not materially suffer beyond sensitiveness of the eyes and the necessity of wearing glasses for good distant vision.

This has been misnamed "school myopia" ; there is, however, a small number of these, or perhaps indistinguishable from these, less than 10 per cent. of the myopes, whose myopia goes on increasing. In later life grave occurrences, such as hæmorrhages, or detachment of the retina, may occur, so that all myopia at first is to be suspect. Probably not 10 per cent. of myopes are in serious danger of visual troubles or risks. The mere existence of myopia affects visual acuity for distance. Galloway (*School Hygiene,* 1919. 90) gives an average scale as—

Visual acuity—	$\frac{6}{6}$	$\frac{6}{9}$	$\frac{6}{12}$	$\frac{6}{18}$	$\frac{6}{24}$	$\frac{6}{36}$	$\frac{6}{60}$	$\frac{5}{60}$	$\frac{4}{60}$	$\frac{3}{60}$	$\frac{2}{60}$
Myopia, in dioptres—	Nil	—0·5	—0·75	—1·0	—1·5	—2·5	—3·0	—4·0	—5·0	—6·0	—10·0

Monocular Myopia.—Monocular myopia holds the chief secret of myopia. For instance, a boy aged 9 is seen with Rt. emmetropic, left = — 12·0 D. Evidently myopia here must be due to some local cause. Syphilis was suspected as a cause of such cases, and two sets of cases were collected by the writer for twelve months. The returns gave for high myopia, from — 6 D. to 16 D., the number of girls 31, and boys 13 ; whereas those found blind and deaf, with the teeth of the Hutchinsonian triad, controls indicative of congenital syphilis, shewed no significant preponderance of girls, the numbers being 27 girls and 23 boys. So that congenital syphilis affecting the sexes nearly equally may be left out of account as a special factor of high myopia, whose incidence is chiefly on females.

Myopia always appears, either quantitatively or qualitatively, more common among females. Indeed, in one of the above cases, the mother was myopic with a well marked annulus, her eldest daughter, aged 12, was myopic to the extent of 6 D., had myopic crescents and a black dot at each macula. The sister, aged 10, had a myopic annulus too, and very red maculæ ; the youngest sister, aged 8, was myopic but without fundus changes. All the ten brothers were stated to be quite normal in vision, and two were in the army.

J. A. Wilson (*Glasgow Medical Journal*, 1913) analyses his five hundred cases as follows—

Table 76.

	Females.	Males.
Low myopia up to 3 D. ..	136	78
Medium myopia 4 D. to 6 D. ..	85	36
High myopia 7 D. to 12 D. ..	72	37
Very high myopia over 12 D...	45	11

Refractive Effects of the Eye on Vision.—Supposing the eye under a mydriatic, in hypermetropia the rays are not focussed, so that a point of light would shew as a diffused spot, the diffusion circle, brighter in the middle. The image on the retina is made up, instead of a number of small accurately defined spots of various colours,

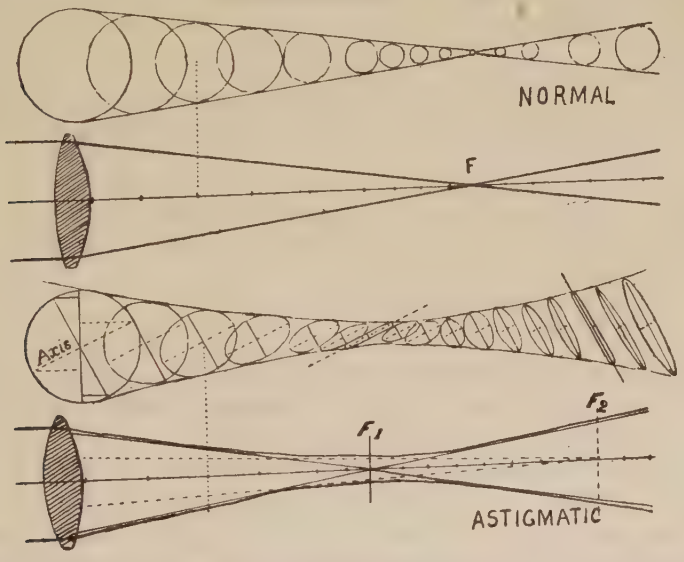


Fig. 104.—ILLUSTRATING THE COURSE OF RAYS OF A CIRCULAR BEAM, AND THE FORM OF SECTION WHEN CORRECTLY FOCUSSED ABOVE, AND BELOW FOCUSSED BY AN ASTIGMATIC LENS.

of a number of diffusion circles overlapping, so that all is more or less hazy.

The greater the amount of hypermetropia, the larger these circles and more ill-defined the image. If the ciliary muscle is not paralysed and sufficient accommodation is exerted, diffusion circles give place to points of light.

In the myopic eye, again the same condition occurs, but here

diffusion circles on the retina are beyond the focus. Where there is astigmatism, there are really two focal distances, F_1 and F_2, corresponding to the two axes ; at no distance is an accurate focus of a point formed (a stigma), and the nearest approach to a clear image is somewhere between these two distances as there the two diffusion circles are smallest and least distorted.

If an eye is taken with refraction in one direction, say nearly vertical, + 3·0 D., and in the other horizontally — 2·5 D., the image of a small circle of light from a distance is accurately focussed as regards its height at 22 mm. behind the cornea, but it is not focussed accurately as regards width till nearly 24 mm. behind. Where the vertical distances are focussed correctly (F_1) the horizontal are still wide apart, and when the horizontal are correct (F_2) the vertical have spread out.

Attempts to correct this by accommodation may mean strain on different sectors of the ciliary muscle.

The three main elements of refraction in the eyes, disturbances of which tend to lowered optical efficiency, or to ocular strain, may be classified as—

1. *Static Refraction.*
   - (*a*) Due to corneal curvature which when uneven causes astigmatism, a congenital defect, tending to decrease very slightly with age.
   - (*b*) Axial refraction due to variable length of the optic axis, when short hypermetropic, when much lengthened myopic.
2. *Dynamic Refraction due mainly to Ciliary Action on the Lens.*
   - (*a*) Spasm of accommodation.
   - (*b*) Functional conditions.
   - (*c*) Monocular polyopia.

Spurious Myopia.—Two conditions are common which may be taken for myopia, as the child fails on distant but easily reads near types. It may manage only $\frac{6}{60}$ but read J_1.

Functional Amblyopia is a condition occurring in nervous, overwrought children. It is common among Jews and foreigners, and most frequent in girls of about 11 or 12. A child who cannot see the blackboard but sees easily close at hand, and has no apparent trouble in the eye, is often growing quickly or, especially about adolescence, is physiologically exhausted. They will see better with the weakest concave, then with weakest convex, then finally with both together, the equivalent of plain glass. In a recent Report of a County M.O.H. these cases are noted as malingerers ; an erroneous idea.

Brudenell Carter, in 1896, in one of the best reports on school children's vision, states : "The fact with which I have been most impressed in the course of the enquiry, is the existence in London of a very large number of children with subnormal vision, for which

their errors of refraction are insufficient to account." He attributed it to psychical factors in town life, and we have noticed that in small children the mental factor is considerable. Much also may be included as functional.

Katz of Petrograd (*Buffalo Congress*, v. 422) said that about 4 per cent. of Russian children shewed these conditions.

A thorough examination of all boys with defective vision in a Bradford secondary school of 330 boys, aged 12–15, found seven with no defect in refraction, muscle balance or otherwise, good healthy boys, with vision $\frac{6}{18}$ or worse. They attained good vision in a few months without treatment.

Auto-suggested amblyopia comes on suddenly. At first near work causes no trouble ; later it is held near and done with effort. Following this, there may be complaint of glare, or avoidance of light and frowning or headaches. Examination of the eye tends to aggravate ; on the other hand, suggestion that vision is improving, with the eyes closed in a dark room, sometimes effects rapid recovery. In some of the writer's cases, Förster's spiral contracture of the visual field characteristic of functional amblyopia was determined. Monocular polyopia may be detected, or actual complaint of intermittent micropsia which suggests relaxation of the ciliary muscle. The writer once proposed the detection of these as symptomatic of hysteria. With growth or return to a healthier condition the symptoms may disappear. Suggestion in some form is often useful, or atropine and exclusion from school. There must be no treatment with concave glasses, for although they sharpen vision they soon aggravate the condition and set up the next variety of amblyopia, due to chronic ciliary spasm of the accommodation.

Thiele, in an inaugural thesis at Rostock in 1910, on auto-suggested myopia, dealt with thirty-two cases. They had it explained to them, and were told that atropine drops would cure them in two or three days. Each one was examined a year later, and they were all nervous, under-developed, ill-nourished children. On examination plane glasses improved the vision (*Munch. Med. Woch.*, 1911. i. 47). It is quite possible that the endocrine disturbances of puberty may be at the root of these temporary functional conditions, especially when headaches are associated.

Cramp of the Accommodation, called also by some of the German writers, lens myopia or accommodation myopia.—The involuntary muscular fibres in the ciliary body, if continuously worked, seem to pass easily into a state of tonic contraction. This may occur in delicate, anæmic or neurotic children who are growing rapidly, or are convalescent from illness. Lancaster and Williams (*Trans. Amer. Acad. of Ophthal.*, 1914) found that in fatigue of the eyes some ciliary contracture was quite common, as shewn by the *punctum proximum*, instead of receding as expected, it approaches

the eye. The *punctum remotum* also approaches. The result indicates that the lens becomes more convex. It is accommodated for a near point, and images which should fall on the retina are now focussed on the axis in front of this. The length of the axis of the eye may be normal, but the cramp of the ciliary muscle making the lens too convex causes this lenticular myopia.

Where myopia is tested by the nearness of clear reading, this form would be included.

In England and America it is not often recorded specially, and seems easily missed, but in German countries one finds it frequently mentioned. It is quite a definite appearance, and like tobacco amblyopia is found if looked for.

Henry Power at the Ophthalmological Society in 1894, spoke of a boy who had worked hard for the Navy, passed his examination,

TABLE 77.

BRUNN, 1909–10.

	True Myopia.		Accommodative Myopia.		Total Apparent Myopia.	
Class.	Boys.	Girls.	Boys.	Girls.	Boys.	Girls.
2	2·6	2·8	2·0	2·5	4·6	5·3
3	2·7	3·0	3·3	2·9	6·0	5·9
4	3·2	3·6	3·7	4·4	6·9	8·0
5	3·5	3·8	4·7	5·4	8·2	9·2
6	4·3	4·0	6·0	7·9	10·2	11·9
7	4·7	5·4	6·5	8·8	11·2	14·2
8	6·0	8·1	9·0	8·8	15·0	16·9

and was turned down for defective vision, but who six weeks later had normal acuity and was accepted then. Critchett referred to three similar cases he had seen.

Dr. Kokall, the Medical Officer for Brunn, reports percentages of myopia in the elementary schools from lowest to highest, distinguished as true and accommodative.

Some regard this accommodation myopia as a stepping-stone to real myopia. In the Report of the School Medical Officer for Zurich in 1906, of 400 boys and 494 girls entering on a six years' elementary course, 156 boys and 204 girls were entered as visually normal; of these, in the last year, 43 boys and 22 girls had become short-sighted, and 10 boys and 13 girls were returned as having spasm of the accommodation. "Candidates for short-sightedness," as the reporter classifies them.

As typical examples of accommodative spasm, either counterfeiting or exaggerating myopia, may be quoted the following illustrative cases.

A scholarship boy obtained $\frac{6}{6}$ with either eye; wearing Rt. — 2·75 D. sph., L — 1·25 D. sph., — 0·75 D. cyl., and was passed without further visual examination. Seen a couple of years later as candidate for the Training College, he was found to have vision $\frac{6}{12}$ and $\frac{2}{24}$, obviously not corresponding to the myopic glasses he had worn. With R. and L. + 6·0 D. he got R. and L. = $\frac{6}{9}$.

A girl of $11\frac{1}{2}$ comes up for a junior scholarship. She is wearing R. and L. = — 3·0 D. sph., with which she gets $\frac{6}{24}$. Ophthalmoscopic examination with contracted pupils shews details clearly with — 7·0 D. She takes increasing concave spheres up to R. and L. = — 8·0 D., with which she reads $\frac{6}{6}$ in either eye. Enquiry shews that three weeks previously she had had glasses prescribed, and that then retinoscopy under mydriasis gave the refraction — 4·0 D. sph., with which she got full acuity.

A girl of 18, well grown and of robust physique, suffered headaches and asthenopia. She bought weak concave glasses and her vision had become worse. Retinoscopy shewed 1·25 D. of hypermetropia with 0·75 D. of astigmatism. She refused to wear the glasses prescribed, returned to concave glasses, gave up her training as a teacher, and was prescribed still stronger concave glasses elsewhere.

Another case was a small Jewish boy, aged 11, wearing — 7·5 D. sph. His father wore R. = — 12 D. and L. = — 10 D. sph. Retinoscopic shadows were reversed in the boy about — 2·5 D. On the further use of atropine the shadow reversed at — 1·0 D. By keeping him under atropine for some time he got normal vision with — 2·0 D. sph. Fifteen years later, during the War, he was seen wearing glasses between — 4·0 D. and — 5·0 D. and getting normal vision.

A nervous girl of 10 years, in Standard IV, had vision of $\frac{6}{60}$, and with — 2·0 D. worn saw $\frac{6}{12}$, but on retinoscopy was found to be hypermetropic to the extent of 1·5 D. and under atropine read $\frac{6}{12}$ with 1·0 D. convex. She was given + 0·5 D. sph. and seen a few weeks later, read $\frac{6}{6}$ wearing it. Later enquiry found her at home with weakness in one arm, probably functional, and throwing light on her original visual trouble.

Inglis Pollock thinks that continued use of atropine may sometimes reduce myopia, and speaks of as much as 4 D. decrease (*Glasgow Med. Journ.*, 1916).

Ivanoff, many years ago, published post-mortem findings of hypertrophied ciliary muscle in some cases of myopia, suggesting chronic spasm in addition to the myopia.

These considerations shew the necessity for mydriatics if one is to be assured of freedom from such errors in prescribing glasses. It is quite impossible without, to prescribe or fit glasses properly

for school children, and no optician, who does not use a mydriatic, can be sure of not aggravating rather than relieving the child's visual condition.

One must also remember paresis of the ciliary muscle as perhaps the only post-diphtheritic symptom remaining, and causing difficulty in reading. At one time the writer saw several cases from the Yorkshire Dales when diphtheria was almost unknown in Bradford. They had come on account of difficulties with school-work.

Most children see better if a weak concave glass is used ; it seems to stimulate them to make an effort at accommodation. It was formerly common to find children and young people who either needed no glasses or else weak convex ones, wearing very weak concave spheres and cylinders prescribed by opticians after simply testing distant vision with lenses. Probably thousands of people in London wear concave glasses who do not need them.

A girl of 9 or 10 years old, admitted to a myopic class because wearing R. = — 6·0 D. sph. and L. = — 5·0 D. sph., was carefully examined some time later and found not myopic ; sent to the school clinic, she was given + 1·0 D. sph. with + 3·0 D. cyl., and transferred to the ordinary school with good vision.

Another child, aged 8, had vision $\frac{6}{9}$ and was advised to have the eyes attended to. Aged 10, vision was $\frac{6}{12}$ and glasses were prescribed, but not obtained. There was no eye trouble, but at 11 the condition was the same. At 12 vision was normal, and after three years' work as a scholarship holder, her vision is still normal without glasses.

Occasionally accommodative troubles may be aggravated by some strain on convergence ; working too near may throw a strain on the internal recti, which they cannot maintain for long. This is certainly sometimes a cause of headache, either frontal or at the root of the nose. There may be giddy feelings on looking down. There often seems a disinclination to do work and want of will as the day's work goes on. When the condition is detected rest from continuous near work should be ordered. Ophthalmic examination and testing of convergence may lead to relief, but the use of prisms or decentring of glasses ought to be left to experienced surgeons.

Numbers Presenting Defects of Refraction.—Proportions, in which the different refractive conditions exist, differ so materially with age and sex that these factors must always be stated. To appreciate the conditions, all normal children must also be included.

It would be worth while making a thorough statistical study of the relations of sex, age, and static refractive conditions, practically the rate of growth of the eyeball. Statutory requirements in England have hitherto excluded any large range of investigation in school hygiene. It is necessary to ascertain the types of normal

growth and range of variation. From these data a few months' observation, or special tests, might enable the selection at early stages of those likely to have progressive myopia, and allow them to be suitably protected during the educational period. In such an enquiry heredity must be given a place as a possible aid in selection, and a series of tests of ocular resistance would also have to be developed. This means an amount of work not to be undertaken lightly.

Bishop Harman, in a paper to the Ophthalmological Congress in 1919, gave the result of retinoscopy under homatropine of 368 infants aged 4 to 7 years. There was good vision in 227, and imperfect vision in 126; in 8 cases glasses had been provided. A brother and sister had lamellar cataracts, 8 were squinters, and 2 had choroiditis.

The refractive conditions were: (i) emmetropia, 8; (ii) hypermetropia, 246; (iii) astigmatism, under 2 D., 62, over 2 D., 38, and mixed astigmatism, 13; (iv) myopia, 6.

The six myopes were respectively of 3, 4, 6, 8, 8, and 16 D. The infant eye begins as hypermetropia and gradually passes in the process of development to emmetropia, and possibly myopia. As in all physiological processes, some fall short of the mean and some overshoot it; so in growth, some eyes are short and some long, whilst the great bulk are nearly correct. The one-third of the Bradford children whose visual attainments were hyperacute may all be put down as hypermetropic.

Carhart (*N.Y. Med. Journ.*, 1897), who examined 1000 village children with the astigmometer, found a steady drop of H. from 53 per cent. in youngest to 23 in oldest groups; H. As. increasing from 33 to 58 per cent., M. and M. Ast. increasing from 2·6 to 6·4 per cent.

Slight degrees of hypermetropia may be missed, or where there is spasm of the accommodation, may even be taken for myopia.

Dr. Hutt, in testing some 7000 children at Brighton, equal numbers boys and girls, mainly between the ages of 8 and 11, found a percentage of 32·7 boys, and 33·8 girls shewed hypermetropia manifest equal to at least 1 D. Dr. Little of Bradford used atropine to reveal the hypermetropia corrected by accommodation.

In 1895, testing 320 pupils at the Bradford Training Classes, about five-sixths being girls, 52 per cent. shewed some manifest H., and 26 per cent. were over 1 D.; 20 per cent. got normal vision with no manifest H., seven were astigmatic, and 21 per cent. had myopia or myopic astigmatism. There were about equal numbers of each age from 15 to 18 years old.

Posey and Tait Mackenzie, examining students' eyes, average age 21·4 years, found 12·75 per cent. myopic in two lower, and 19·75 per cent. in the three higher classes. There was an increase of 2·5

per cent. with myopia in the four years course. Of the 894 students, 303 wore glasses, 217 convex and 86 concave, and 87 suffered headaches, of whom 92 per cent. had perfect vision and did not suspect an ocular cause for the headaches.

The Liverpool eye surgeons refracted children in 1921 mainly of the ages 8 and 12 years. They found hypermetropia 1085 or 36 per cent.; with astigmatism, 981 or 32·7 per cent.; myopia, 276 or 9·2 per cent.; with astigmatism, 356 or 11·9 per cent.; and mixed astigmatism, 218 or 7·3 per cent.; emmetropia only 61 or 2 per cent., and 23 not possible to determine.

The majority of eyes are hypermetropic, although many appear to become astigmatic, as the hypermetropia shews up relatively

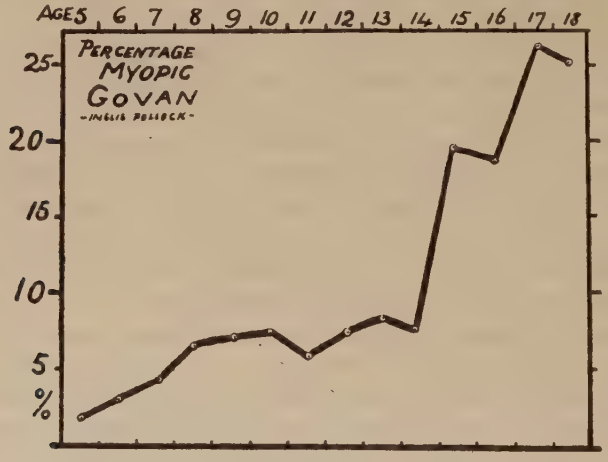


Fig. 105.

with lessening accommodation, and as time goes on, with increasing age, may pass on to myopia.

How this is misunderstood is seen from the Report of a County Medical Officer, who discusses the decrease of hypermetropia in secondary schools of his area as if it were an advantage promoted by medical inspection (1924).

In a paper published in 1906 by Inglis Pollock (*Trans. Roy. Phil. Soc.*, Glasgow), he gave the age distribution of myopia as determined by retinoscopy in 6364 Govan children from 5 to 18 years old.

Here is a slow increase, from about 2 per cent. at the beginning to about 7 or 8 per cent. at the end of elementary school-life; with a great jump to 15 per cent. and more among those who survive the selection into the secondary school. At least 10 per cent. of the children passing out of the elementary school have become myopic.

Myopia and Public Health.—At first myopia was confused with

asthenopia and other conditions with poor distant vision. In 1812 Ware, in Chelsea, found three short-sighted children among 1300 in the army schools, whilst he found 32 out of 125 Oxford undergraduates who used glasses. In the middle of last century, about 1840, there was anxiety in Baden, which led to investigations by teachers who returned up to 50 per cent. in some of the secondary schools as short-sighted. With the introduction of the ophthalmoscope by Helmholtz in 1851, a better means of investigation was afforded, and in 1864, Donders, the great Dutch ophthalmologist, who put the refraction of the eye on a sound basis, wrote: "I declare without hesitation that a myopic eye is a diseased eye." He took a serious view of myopia and was opposed by most of the ophthalmologists of his time.

In 1866, Hermann Cohn came into the field. His work dominated both the next generation and English text-books almost to this day.

The Work of Hermann Cohn.—He entered the Gymnasium with normal vision, and in the next four years became himself myopic to the extent of 5 D. He began work in Breslau in 1863, and in 1866 published the results of examination of 10,006 children. His figures may be summed in percentages of myopia which he found.

In five elementary schools, 1·4 per cent.; twenty town schools, 6·7; high school for girls, 7·7; two middle schools, 10·3; two higher modern schools (*Realschule*), 19·7; two classical schools (Gymnasia), 26.

He stated that the amount of myopia increases on proceeding from village school to grammar school, and added that there is an increase in degree of myopia from class to class in all schools. On the other hand, Karl Pearson deduced from Cohn's own statistics (*B.M.J.*, July 1909) that the later the child went to school the worse at a given age the myopia. "Cohn's statistics are very suggestive because they have hitherto been supposed to prove the exact reverse of what is extractable from them." Cohn devoted himself to myopia, piled statistics together to prove his points, and worked out all kinds of facts to shew that myopia was due to continuous close work in bad light. These results of half a century ago have to be much discounted. For instance, in his 10,000 children, Cohn only recorded 239 or 2·9 per cent. with regular astigmatism.

Meanwhile Donders had modified his views and reached the classification that myopia exists in three forms—a stationary, a temporarily progressive, and a continuously progressive. He demonstrated that among rural dwellers, not town folk, the highest quantitative degrees were found.

The Prussian Government, on account of importance of myopia to the army, called in Virchow, who agreed generally with Cohn.

Soon after Cohn, Erismann in 1871, being then in Moscow,

shewed that the usual condition in children was H., which passed into E. with or without astigmatism, and some went on to M. From the Moscow schools, Erismann worked out the refraction of the eye in relation to class in school in percentage.

In 1876, Von Arlt, the Viennese professor, maintained from his own personal experience and that of two other colleagues, that myopia was acquired through excessive eye-work, agreeing with Cohn. About the same time, Seggel, in Munich, from examination of recruits, stated that high grades of myopia were commonest in classes occupying themselves little with near work. Landolt, in 1879, the Paris ophthalmologist, reviewed the whole matter, setting out views much as now accepted.

About 1881, a reaction against the pessimism of Cohn and his followers began. Donders stating that " The lower grades of myopia give a capacity for fine handwork, and for scientific investigations which we cannot do without. Truly, if it lay in my power to abolish

Table 78.

Class.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Hypermetropic	68	56	50	41	35	34	32	36	40
Emmetropic ..	19	28	26	27	26	24	25	21	18
Myopic ..	14	16	22	31	38	41	42	43	42

all the short-sightedness in the world I would not do so." He thought that in myopia we see one of many examples, wished for within limits, of the adaptation of an organ under the influence of use.

Stilling, in 1886, wrote that myopia was often one-sided and could not then be due to work.

Many military observers noted high degrees of myopia in the least educated. This was put on a proper basis by Tscherning (1880) examining Danish recruits aged 22 years. He made 6 classes.

1. Students, 32·3 per cent. with myopia.
2. Shop assistants, 15·7.
3. Badly educated folk, 13·3.
4. Fine workers, 11·7.
5. Coarse workers, 5·2.
6. Daily labourers, 2·4 per cent., but taking high myopia over 9 D. it appeared more frequently in the lower strata.

Re-examining other statistics, low myopia is seen related to much eye-work, high myopia in origin independent of it. The definite cause of myopia is quite unknown. Every hypothesis or theory to

account for it fails when clinically tested. There may be many contributing factors. The essential matter is that there is a certain constitutional build of eye liable to myopia, possibly from congenital defect of the sclerotic.

Leaving out of account rare cases of high grade myopia, which may be congenital, and which do not materially progress, there remains a large number of cases of developmental myopia. All eyes tend to lengthen their axes, the majority stop before the 23 or 24 mm. which constitutes emmetropia is reached. Many, however, reach this, and somewhere about 10 per cent. of English children exceed it. Donders recorded a case which reached 37 mm. The majority of these have irregular spurts of stretching or growth, particularly during convalescence from illness, and also in early adolescence. Some very obscure factor in growth nutrition is acting. Most have the stretching practically arrested by 20 years of age, and in the next 5 or 10 years do not increase a dioptre. A small number, about 1 per cent. of children, do not have this arrest, but continue still to have increase and become liable to all kinds of ocular accidents.

About 85 to 90 per cent. of elementary school children go through their course without "school" detriment to their eyes, however bad the school. It is the 10 per cent. who are predisposed to suffer, and the real problem is, if school causes an increase in myopia, how are the risky cases to be distinguished ere they go wrong ?

Heredity was ascribed as a factor by Donders, but he carefully added that it was the disposition to myopia that was inherited. The disposition seems about twice as common in girls as boys. The parent may have 1 or 2 dioptres, the child 8 or 10, or *vice versa*. It is certainly not the main cause, but it is a very constant factor.

Dr. J. A. Wilson (*B.M.J.*, August 29, 1914) worked over 1500 cases of myopia thoroughly, and stated that it was hereditary in 58 per cent., with a tendency to sex limitation. The mother seems to transmit it most frequently.

The hereditary factor is undoubted in many of the cases which exhibit high degrees. Often it comes out in a strange way. A girl with myopia of considerable amount, whose friends objected to my decision, on re-examination, stated that her mother, a school-keeper's wife, was unfit for work on account of detachment of retina. Another girl with refraction over — 8·0 D. appealed because a scholarship was refused, and stated that "Mother couldn't come. Mother manages business in the city, father's sight being what it is, since he was 30, when he had detachment of the retina." They were both quite fluent with the phrase "detachment of the retina," but apparently had no idea of its cause. Another boy was rejected for the building trade on account of myopia. His mother asked for compassionate treatment as he had only recently lost his father, who

was a builder and, being very short-sighted, had unfortunately walked over a scaffold. Just what she had been warned five minutes before might happen to her boy. These cases are quoted to shew also the difficulty which the doctor meets in having his decisions accepted.

The Accommodation Theory of origin almost follows from the muscle spasm already described as a cause of pseudo-myopia. At the beginning of the myopic change in eyes there is a decided tendency to ciliary spasm, and when one hears of myopia reduced by treatment, mistaken diagnosis of ciliary spasm is to be suspected. Over use of the ciliary muscle occurs in hypermetropia without any tendency to myopia ; on the contrary, the more myopia, the less the accommodation strain, and accommodation spasm must be looked on as a result or accompaniment of the eye conditions leading to myopia.

Convergence is supposed by others to be a main factor from pressure of the internal recti on the globe, but it also occurs in hypermetropic children without evil effects, and myopia occurs in individuals with external squint who have never converged. Indeed, the greatest convergence is in internal squint, mainly with hypermetropia, and not with myopia.

The Trochlear Theory that the superior oblique muscle in low orbits presses unduly on the globe was propounded by Stilling, in 1887, but was found anatomically incorrect ; besides, it is quite discounted by monocular myopia. Various other theories have been propounded, that there is a tension exerted by the optic nerve, that the weight of the eyes in looking down cause stretching (Levinsohn), and that tension in the eyeball as from muscular exertions, especially with eye directed down, cause hindrance to lymph outflow, resulting in stretching and myopia (Edridge Green). Cohn adhered to the near work idea, that myopia is mainly caused by near work over which the head is bent, especially in poor light. This is the favourite practical solution, but here again it does not explain monocular myopia, and to 80 or 90 per cent. of school children these factors mean no harm. It is only in the children who are becoming myopic that the effects seem aggravated by near work, as will be further discussed in connection with glare.

J. A. Wilson (*Glasgow Med. Journ.*, 1913) associates myopia with keratitis ; on the other hand, A. F. MacCallan, who had 50 per cent. of his Egyptian pupils with corneal opacities of some kind, states that he finds no evidence to connect this with myopia (*B.M.J.*, November 1, 1913). The ordinary physiological variation of structures would predict a refractive distribution in accordance with the curve of error, so that a certain amount of myopia is to be expected normally, independent of work ; further, in cases so disposed, a multitude of nutritional factors, nervous reflexes, and

so forth, may aggravate conditions so that one hardly expects to assign any single factor as causing myopia.

General good eye hygiene is undoubtedly prophylactic, and bad is, on the contrary, aggravating to the tendency.

As the myopic eye stretches back it becomes thinned. On examining the optic nerve head with the ophthalmoscope, in a series of eyes, the disc appears round or oval, the last in astigmatic cases, but in many myopic cases there is a thinning like a crescent moon around the outer side of the disc, the myopic crescent. In advanced cases the crescent extends, till in high myopia one finds an annulus round the disc, or the disc may appear a small object in the middle of a large irregularly oval or circular white myopic staphyloma. Bishop Harman suggested that the seriousness of myopia might be graded by the changes in the fundus of the eye, as first, second, or third degree according to the width of the atrophy around the disc whether it was a half, whole, or one and a half the disc width.

Steiger (*Die Entstehung der spharischen Refractionen*, Berlin, 1913) brought out the hereditary element of causation strongly against the mechanical overuse theory, and recently Vogt (*Klin. monat. f. Augenheilk.*, 1924) has set out that growth of the retina is the essential cause, leading to the elongation of the eyeball to accommodate it. He compares the senile changes of the fundus with the changes of advancing myopia.

Later in life there is a tendency for changes in the vitreous, it often becomes fluid, and specks and sometimes masses of tissue float in it. There may be circumscribed degeneration about the macula or atrophic changes beginning at the disc, the crescent or annulus may extend till the macular retinal structures also waste, or hæmorrhages occur, especially about the macula. These are dangers which the work of Cohn and others made appear extremely serious to all myopes.

Although the seriousness of myopia is not so great in England, still, even during school-days, 4 or 5 per cent. of the blind are attributed to this cause. It runs to about 14 per cent. of all the blind. The chief results are after 30 years of age, so that it is prudent to look on high myopia in a child as an ominous portent for vision in later life, and, at any age, for myopia of 10 D. the future is risky for efficient vision.

The hypermetropic eye is likely, if there is any considerable shortening of the axis, to cause trouble as the accommodation weakens, and to require glasses for near work sooner than the average individual. With astigmatism, this may cause pain and discomfort. Yet vision may be so good with the constant accommodation exerted that no suspicion arises of vision as the origin of various nerve troubles. The myope, on the contrary, if this is moderate

in amount, has few troubles beyond the increased sensitiveness of the eyes to glare or strain of any kind, and perhaps a general accompanying tendency to migraine. Later on in life, near work is done easily. Many a person who has had myopia uncorrected goes on to advanced years never wearing glasses, but the myope does not usually wear so well for eye-work in later adult life, and is remotely liable to the risks already mentioned.

These considerations arise in connection with trade scholarships and with candidates for the teaching profession.

Many trades do not do well for those compelled to wear glasses, and others entail strain that with considerable refractive errors cannot be compensated, but for most the trouble will come ten or a dozen years ahead.

Correction of Refractive Troubles.—The treatment of anomalies of refraction is by glasses. Retinoscopy under a mydriatic is indispensable in all who are not full grown. It is invaluable as a guide. Lenses may then be tried to correct the refraction.

It has never been demonstrated that every error of refraction, even with diminished visual acuity, in a child needs correction by glasses. There is just the possibility that the wearing of glasses may do harm in many cases by removing the corrective influence of muscular efforts to get clear images.

In cases of spasm the glass which gives a clear image makes the ultimate condition worse. For the majority of children wearing glasses, a more rational use of the eyes in educational work may give better results than are now being obtained. It is not only the prolonged use of the eyes on near and small objects, but also their continued use in defective light which is one of the chief defects in modern education.

The accommodation of children is so great that it is well to leave something to this, and where astigmatism is not of high degree, and where there is no squint, children are just as well with spheres at first. Where there is astigmatism in the young child, the full correction will prevent any natural attempt during growth to remedy the condition either by sectoral hypertrophy of the ciliary muscles or otherwise, as R. W. Doyne (*B.M.J.*, 1910. ii. 361) puts it, "The ciliary muscle can be 'Sandowed.'"

Prof. Maitland Ramsay, in 1904, strongly dissented from the above suggestion in the writer's Reports, of using simple glasses for young children, but it is quite reasonable, and works out well in practice. The majority give them up permanently in a year or two. Probably there is now, even more than at that time, need to insist as above that there is too much mechanical prescribing of weak spheres and low cylinders, in what may be called "fancy glasses," without regard to the *vis medicatrix naturæ*. The story occurs to one's mind of the thirty American Indian children sent to Phila-

delphia to be investigated visually who were returned to their Western Reservation with twenty pairs of spectacles.

Children seen wearing glasses at medical examinations should always have the strength measured and noted. This can be done either by neutralizing the glasses with a corresponding glass from the trial case, a rather inelegant method, not to be compared to the convenience of measurement by the Geneva lens measurer or spherometer. Where the face of the glass to be measured is spherical the measurer indicates the same number of dioptres in any direction. The measure of the lens is the algebraical sum of the readings of the

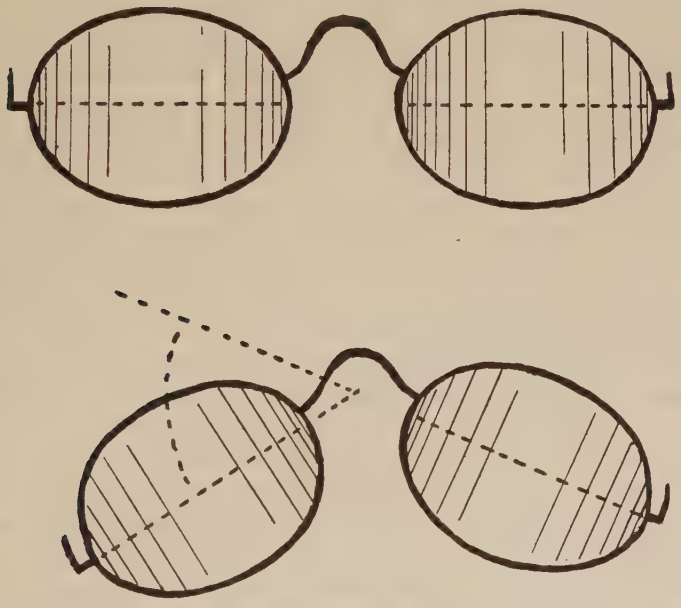


FIG. 106.—CYLINDRICAL LENSES IN SPECTACLE FRAME, SHEWING DISTORTION OF EFFECT FROM BENDING OF FRAME BRIDGE.

two faces. A — 3·0 D. spherical lens may thus probably read — 1·5 D. on each face, or if periscopic may read — 5·0 D. on one face, and + 2·0 D. on the other. If, however, one side of a lens has a cylinder, the lens measurer when its three points are parallel to the axis of the cylinder will read zero, and on turning it about on the glass it will give its maximum reading, the curvature of the cylinder at right angles to this.

There is the toric variety of lens sometimes seen where the surface is not spherical or plane in any direction, but a combination of two cylinders, like the curved outside of a large cheese. The readings must again be algebraically added along the two corresponding axes. Owing to the reflections from the convex fronts they are very ugly to wear, and of no ophthalmic benefit corresponding to

the cost. Toric lenses are an absurdity for children, so are bifocal lenses for their near and far work. Such foolish and costly prescriptions from ophthalmic hospitals have been given even to feeble-minded children. Spectacles should always be prescribed with curled sides. The bridge should not be brittle. Often strong cylinders are seen worn by a child in spectacles where the frames are so bent that the glasses are turned through sufficient angle to make them worse than useless. By merely straightening the frame sometimes a child is found to read more lines of the test type. Where cylinders are prescribed, the glasses should be worn constantly, wearing them intermittently by older children or adolescents occasionally may set up considerable strain or headache. There may be difficulty in following up, to make the children get or wear glasses. It can be got over, however; at Bristol, in the case of 1771 children, 1452 were ordered glasses, and all except five obtained them.

Spectacles were rare and curious things at first. There is a picture dating from A.D. 1466 of the three Holy Kings, one of whom looks at the Sacred Infant through eye glasses. When the Low Countries began to manufacture them in the seventeenth century, so many young people wore them that it is noticed in contemporary writings (Kotelmann). Sometimes children cause trouble by exchanging each other's glasses in schools, so that it might be worth while stamping frames with a letter and number to prevent this.

School Treatment of Refraction Cases.—Children when first seen in school occasionally present refraction troubles. H. and H. Ast. being the common, M. rare. Owing to the great range of accommodation, much H. or even H. Ast. is likely to be missed by the ordinary acuity tests. It should be particularly expected in children with chronic affections such as blepharitis, granular lids, or, of course, squint. The troubles of the ordinary hypermetrope are not likely to become obvious till later than school-days. In the writer's experience, headaches from purely ocular causes in primary school children are uncommon. Fine work, sewing, reading, music, may begin to cause trouble when the higher standards are reached. In secondary schools and with nervous children, all kinds of effects may arise with hypermetropic astigmatism.

Myopia usually increases during the whole growing period. This accounts for much of the influence assigned to school-work, although school-work does not make 90 per cent. of the children myopic. It is to be expected that if carefully observed there would be a seasonal variation in the progress, more rapid in late Spring and early Summer, than in the rest of the year.

As far back as 1864 Donder's book on Refraction gives a very clear account of the life story of myopia, setting it out in three classes, the stationary, temporarily progressive, and permanently progressive.

Sometimes a case begins early, and at first may be missed at

school till the child is found with very defective vision. Often, indeed, all kinds of tricks are resorted to to avoid visual testing.

Two types of myopes emerge : the small, delicate child of 9 or 10 years old with 1·0 D. or 2·0 D. of myopia who probably says she wants to be a teacher, and is of the *type cérebrale* of some French anthropologists ; or the fat, heavy type, suggesting endocrine faults, who often has a high myopia at an early age, rapidly progressing. The average myopic child of low degree has a well-developed brain, which, perhaps, is associated with an over-developed eye.

Definite myopia, which appears by 10 or 11 years of age, then may be noted as up to a couple of dioptres. This may be expected to double by 16 years of age, and add an equal amount ere full growth is attained, when it probably becomes quiescent from the age of 20 to 25.

It is quite impossible to say how much school-work contributes to the aggravation of the condition of myopia. Possibly 50 to 60 per cent. would be a full estimate, but these eyes are not made myopic by school. Some of the German writers deplore that school palaces have done nothing to diminish the prevalence and intensity of myopia (Levinsohn, *B.M.J.*, 1912. ii. 1312). Girls seem to shew more myopia than boys, but the contrary is stated to be the rule among the Jewish children of the East End of London, where so many small boys pore over the Scriptures in the Chaida, and accentuate their racial tendencies thereby.

Whatever be the story, at the age of 11 children have to be chosen for scholarships or secondary education. There is now a serious question arising in connection with certain scholarship candidates of 11 years of age. These are the children who with glasses can get fair vision, and who consequently often have not been detected at school as suffering from myopia of considerable amount. Myopia at early ages, if it changes at all, changes for the worse, and as there is generally a great increase at puberty and during the rest of growth, it is important to preserve such eyes as well as possible till growth is accomplished. The claim put forward in the *Board of Education Report* (1917. 60) that a child unfit with myopia can have it rendered stationary by open-air treatment so that in a year or two it may return to the elementary school should have been condemned. Any child of 11 to 12 years of age with myopia equal to 4·0 D. or more is to be regarded as likely to be harmed in vision by further academic work in the sense of reading or writing, or fine work like drawing or sewing. These particular candidates are often precocious intellectually ; they have gained a scholarship, their ages average $11\frac{1}{2}$ years, and they must stay at school till 14 at the earliest ; they have probably attained the Standard VII, hence to remain at the ordinary school is merely marking time. On the other hand, they cannot be regarded as in

any sense blind or half-blind, and the myopic schools are probably far below their scholarship standard. These children are of incomparably more value to the community than mentally defective, crippled, or tuberculous children, and special education, somewhat on the lines of the myopic schools, should be adapted to them.

Every child with 2·0 D. of myopia, by the age of 11 should be put under half-yearly reports, partly for safety, and partly for parental education, and with — 3·0 D. or more should be rejected for scholarships.

Bishop Harman (*Lancet*, October 28, 1922) compared two sets of myopes, those of 3·0 D. to 5·0 D. engaged in continuous close work 33 per cent. shewed failure in work, from — 5·0 D. to — 10·0 D. shewed 60 per cent., and over — 10·0 D. had 77 per cent. failure. The whole of these myopes shewed a failure of 53 per cent., whereas myopes of the same order who did not engage in near work failed only to the extent of 9·4 per cent. His judgment for education is taken by summing the four meridians, dividing by 4, and taking that as the refractive basis. If this is over — 2·0 D. at 11 he rejects, — 3·0 D. for the sixteen-year-old, and — 4·0 D. for twenty-one-year-olds. There is much opposition to these rejections by parents, head teachers, and even doctors.

A boy of 11 years old, V.A. = $\frac{6}{24}$ with glasses, referred for further examination, is provided by an ophthalmic surgeon with L. = —3·0 D. sph., Rt. = —7·0 D. sph. —1·5 D. cyl., and a certificate that he was fit for a scholarship.

A boy of 11½ years old, wearing — 4·25 D. sph., referred for vision examination and to have "easy treatment" at school (p. 529), is provided with R. and L. — 6·0 D. sph. — 0·25 cyl., and is certified "will be capable of continuous study so far as eyesight is concerned."

A girl, rejected as an entrant for training for the teaching profession, brought a certificate from a surgeon: "I see no reason why this girl should not have a scholarship, provided she does not overdo near work, and she should not do any unnecessary work as reading novels, nor should she read at night. As her myopia has increased from — 3·25 D. to — 8·0 D. between May 1921 and January 1922 she should be kept under observation at the hospital."

In considering the vision of any child with a view to its future, many cases of asthenopia should be warned off trying occupations. Details of various occupations classed as "fine work" and "very fine work" in respect to vision are given in an appendix to the Third Report on Lighting of Factories (Cd. 1686. 1922).

Again, extraordinary cases are found, like a girl aged 20, just out of a training college, who requires Rt. = — 8·0 D. sph.

— 5·0 D. cyl., and gets V. = $\frac{6}{18}$; with the Left she takes — 13·0 D. sph. — 6·0 D. cyl., with which she gets $\frac{6}{36}$. Although she had been accepted by the Board of Education and passed as fit by the college doctor, she should have been rejected much earlier as quite unfit for teaching work.

It is best now to adopt for all cases in which there is any doubt or possibility of difference of opinion, a definite standard. In 1924 the British Council of Ophthalmologists published a Memorandum advising standards as "In the interests of the community and of the individual it is important that scholarships and teacherships should not be granted to candidates suffering from such ocular defects as may be aggravated by long-continued study and lead to inefficiency or incapacity in later life."

Their recommendations were summarized as follows—

Visual Acuity.—In all candidates for scholarships and teacherships the visual acuity with correcting glasses should be not less than $\frac{6}{9}$ in the better eye.

Myopia.—A child of 11 with less than 2 D. of myopia in either eye should be passed. A child of 11 with more than 2 and less than 3, on probation, should be re-examined every six months.

A child of 11 with 3 or more dioptres of myopia in the better eye should be rejected for scholarship training.

At the age of 15 those with more than 4 D. of myopia in the better eye should be deemed unfit to train for the teaching profession.

Entrants to training colleges who are, as a rule, about 18 years of age with more than 5 D. of myopia in the better eye should be rejected.

Astigmatism.—Simple myopic astigmatism, exceeding 3 D. in the better eye, should be a cause of rejection of candidates both for scholarships and for training as teachers. In cases of compound myopic astigmatism, unless the myopia is stationary, astigmatism of even 2 D. may be a cause of rejection.

Cases of hypermetropic astigmatism should be rejected only if visual acuity with correcting glasses in the better eye is less than $\frac{6}{9}$.

Hypermetropia.—This defect should not be a cause of rejection unless vision with correcting glasses in the better eye is less than $\frac{6}{9}$.

If there is only one eye, or if there is only one useful eye, the other being amblyopic from non-progressive disease, which in no way affects, or is likely to affect, the good eye, the case should be judged on the condition of the good eye.

Special Cases.—In the case of candidates for University and Technical scholarships, or those intending to specialize as teachers of certain technical subjects, greater latitude may be allowed after consideration of special circumstances as to nature of work, condition of the candidate's eyes in other respects, etc.

The further treatment of the children rejected as having unsatisfactory ophthalmic conditions, either as respects visual acuity or refractive conditions, is dealt with on page 528, where subnormal conditions affecting education are set out.

The flat-footed scoliotic child is popularly supposed to be pre-

disposed to myopia, but facts do not bear this out. An enquiry in Cologne (*Zeit. f. S.*, 1892. 327) shewed that myopia could not be the cause of scoliosis in girls. In an unpublished enquiry by Dr. Mina Dobbie, about 1910, on 731 children between 12 and 13 years of age carefully analysed out as regards spinal conditions, 34 per cent. boys and 28 per cent. girls were noted with quite normal spines, but good vision was more prevalent in the children selected as having spinal defect.

Sidney Stephenson, in the East End, found the proportions of children myopic, Jew boys 6 times, and Jew girls 3·5 times, as often as Christians, and Nicati in Marseilles, in 1879, noted myopia in Christians 8 per cent., in Jews 15 per cent.

Combe's Reports in Lausanne shew myopia among the Vaudois (French) children as 4 per cent., but in the German children 7·7 per cent. Among the French-Swiss teachers it amounts to 14 per cent., but in the German teachers is 24 per cent. These are all inhabitants of the same town and district, but differing in racial inheritance.

If London is considered in three divisions—North, South, and East—external diseases of the eye as well as visual defects are excessive in the East at all ages in school, but there is less bad nutrition, and less dental defect in those districts, so that racial factors seem stronger than environmental.

In Sweden, where the amount of myopia had been observed over a series of years, a diminution has taken place in the past generation. The fall is not due to any selection or alteration in methods of classification as it is general in all Swedish schools. Widmark and Ask, who have reported on this (*Paris Cong.*, iii. 821) note the myopic as less than half the numbers formerly. Widmark put the diminution from 24·5 per cent. in 1895 to 17 per cent. in 1905. Secondary schools of Stockholm and Upsala gave 28·3 per cent. myopes in 1882–4, and only 12·6 per cent. in 1905; 10 schools in other parts had 23·2 per cent. in 1882–4, and only 9·8 per cent. in 1905. The Swedish regimen of youth has been changed. Gothic print has given place to Roman. Classical studies have been largely replaced by modern, and sports and exercises have been more widely introduced and practised. "Large open spaces and recreation areas, duly provided with supervisors and game organizers . . . is what we need," says Widmark.

It may be safely stated that at least 10 per cent. of the children going through school shew some form of strain, and develop some myopia. Whether this is wholly a disadvantage has been part of the historical discussion of the subject. Our educational authorities have done next to nothing in regard to the ocular hygiene of education. This is probably from want of knowledge. There will be little hope of advance till definite enquiries in the national interest have enabled judgment on—

1. The best means for school use of determining and recording the real visual acuity in children at various ages, as an efficient visual factor.
2. Standardizing the most satisfactory methods for rapid and sufficient accurate determination of refraction in children.
3. The tests for selecting at an early age children whose eyes are likely to suffer from over-use, and the numbers for whom modification of the curriculum is required.
4. The ocular conditions which about the age of 11 should lead to rejection of children for scholarship training, and at the age of 14 or 15 for training as teachers, or for higher or technical education.
5. There should be a demand for definite research being carried out under the Education Authorities in regard to ocular hygiene, as yet wholly neglected apart from vision-testing in schools.
6. Education below the age of 11 is in need of drastic revision and curtailing, in regard to scholastic and academic subjects, to mitigate its many evil physical and mental effects.

Hygienic Treatment of Visual Defects.—There ought to be educational provision for good hygiene.

1. Of the normal and weak eye from strain and glare.
2. Of eyes with diminished acuity or tendencies to disorder.
3. The educationally blind.

Hygienic treatment of the eye in school-work means avoidance of eye-strain.

Glare.—Eye strain is essentially due to maintained efforts at compensation for poor images, by the various mechanisms and adjustments already described. The problem of seeing in poor light is but little different from that of seeing in excessive light. The study of glare is therefore fundamental in school hygiene.

Glare is essentially subjective, depending entirely on the eye. Some eyes being more tolerant than others gives a hint as to the line to follow in attempting an early selection of cases likely during school life to eventuate in myopia. So far the field is unexplored.

The main function of the retina is the recording of changes of colour and brightness on its nerve endings. Where any unvarying condition exists visual record is absent. The blind spot is not noticeable, the shadows of vessels are only seen if the light is shifted so that they are thrown on an unusual part.

Refractive conditions pure and simple can almost be discounted here, as they are persistent, or can be remedied by glasses ; at the most in hypermetropia or astigmatism they load the accommodation or somewhat hamper convergence. The important factor, as it is rather slow, is adaptation of the retina for light or dark, the " adapted " eye being hundreds of times more sensitive in darkness than in brightness. Coming from a dark room, daylight seems glaring, and motor lamps dazzle at night, worse in the blackness of a country road than in crossing Piccadilly Circus. The eye integrates the average illumination about the macula, and adapts itself accordingly.

Little attention has been paid to colour. Visual acuity with red light is as good as with white or yellow, but very poor with blue. On the contrary, rapidity of reading is worst with red and best with blue. The use of the blue-tinted daylight lamps, although costly in electricity is cheap in visual fatigue to those who work at night (*Zeit. f. Hyg. u. Infection*, Bd. 105. s. 27).

The quantity of light passing through the pupils is regulated *instanter* by the contraction of the iris in bright light, slowly dilating as the retina becomes adapted. A slow flicker which just stimulates the pupil may be very irritating. In the case of near objects being looked at there is also a contraction of the pupils, cutting off the peripheral rays which from the spherical aberration of the eye might have interfered with the clearness of the retinal image. The accommodation of the lens for different distances of objects is almost instantaneous.

Another mechanism little noticed, the compensation for want of achromatism in the eye, comes in with violent colour contrasts. All the rays in the eye always being bent towards the axis chromatic aberration occurs. There are several overlapping coloured images. If the red rays are clearly focussed, the image formed by the yellow is somewhat out of focus, and that formed by the blue rays still more so. Probably accommodative adjustments are being made all the time for the various foci in the way the microscopist uses his fine adjustment to visually penetrate a section. If an advertisement, as seen on the Underground, is noticed where bright green and red letters occur on a black background, the subconscious efforts to adjust accommodation to compensate for the chromatic aberration of the red and green causes mistaken judgment of distance, and the red letters thought to be nearer appear to stand out in front of the general level.

These mechanisms are in constant play. Very accurate detail is not physically wanted, and probably not considered in most visual affairs. The silhouetted image is filled in mentally from previous experience, although subconsciously a clear image is sought by the ocular mechanisms. Clear contrasts in the image require rapid removal of the metabolic products formed by light from the visually sensitive material; if this is not done after-images result, persisting and interfering with visual contrasts. Unfocussed light falling on the retina as a haze may mar the contrasts, or if its brightness approaches that of the focussed image, obliterate it. The two last conditions also occur intrinsically. Malnutrition or interference with the retinal circulation causes after-images from the sluggish removal of waste products in the retina. One of the earliest signs of migraine often preceeding the headache is glare from the persistence of after-images. So, too, in toxic, fatigued, or exhausted conditions *muscæ volitantes*, the shadows of little cells and obscurities

in the vitreous, usually unnoticed, set up after-images which are noticeable and sometimes obtrusive in consciousness. In neurasthenia persistence is also frequent. The upper halves of the retinal surface, lighted usually by the comparatively dark images of the foreground in the field of vision, seem more sensitive to light flux than the lower halves, used to the image from the sky. The myriad sparkle of the summer sea, sunshine on the dusty road, or snow upon the mountains may thus become intolerable. The wanderer notices no glare till he lies down on his back, but even a grey sky may set up glare when its image falls on other than the usual lower half of the retina.

All people have some irregular scattering of light entering the eye, but so much is destroyed by the dark pigments that it is scarcely noticed. In investigating eye movements in reading, Dodge found that in fixation the eye is not absolutely steady, but makes continually a series of small, irregular movements as it were to keep the macula nearly corresponding to the object fixed. On fatigue, these movements get larger and more irregular. Dearborn speaks of "fixation field" rather than "fixation point." So long as extreme effort to get an exact image has not to be made, either from poor light, or from watching a small object, no glare may be evident.

One afternoon on a country railway platform, there was no sense of excessive light, the face of the electrically driven clock was clear and bright in all its details, but on carefully watching the tip of the minute hand for the half-minute move forward, the sense of glare soon became insistent, to vanish as soon as the steady attention to one point ceased.

Subjective feelings do not admit of measurement, and so diminished acuity of vision has been used as a measure of glare effects, but probably can only be correct with the same external factors, as diminution of visual acuity by side light on the eye is not proportioned to glare effects generally. Attention is a variable quantity. In listening to a low-ticking clock in the night, its beat is heard to wax and wane. The images on right and left eye by suitable means, such as the stereoscope or Harman's apparatus, seem to alternate in brightness. Visual acuity varies hourly. Side light falling on the eye decreases vision the nearer it is to the line of vision. This is due to haze from internal reflections, as it is greatest when the light falls on the insensitive white optic disc. The internal reflection means unfocussed light, veiling images on other parts of the retina. An artificial haze made by throwing the same light reflected from a clear sheet of glass at 45° with the line of vision, reduces acuity still more. Glare then reduces vision, through scattered light reducing contrast in the details of the retinal images. P. W. Cobb has gone into the whole matter thoroughly (*American Journal of Physiology*, November 1, 1911).

The Causes of Glare.—Intrinsic brightness of sources of light causes after-images. The effect on the retina produced by every image should be transient, but in the case of dazzling by very bright images, the confusion, although only functional, is of considerable duration.

In rare cases, as in watching an eclipse of the sun without a guard of suitably smoked or tinted glass, a permanent scotoma, from actual burning out of the finer retinal structures, results. Less effective degrees only recover after hours or days. A person walking westward on a sunny afternoon, on closing the eyes, may see numerous large black spots in a row, after-images of the sun, although it has not been specially looked at. These are examples of glare from actual intrinsic brilliancy of the images on the retina, even when it is best adapted to receive them. This particular variety is often spoken of as dazzle from high intrinsic brilliancy, glare being kept for discomfort from lower brilliances, but the distinction is rather a refinement.

In connection with modern lighting problems, where the sources of light are hundreds of times more brilliant than those of the last generation this cause of glare is important. No source of artificial light in school or house should be visible which presents a higher intrinsic brilliancy than 3 candle-power per square inch. Electric filament lamps whose brilliancy by the square inch may be reckoned by the hundred or even thousand, and the incandescent gas mantle should never be exposed to the eye, but constantly shaded. Prismatic glass shades and ribbed glass do not always get rid of glare, although they help to diffuse illumination, and for ideal results even they should have opalescent coverings. By this means a large uniform brilliant surface is possible of a degree which does not cause any glare, even when directly looked at.

Adaptation of the Eye to Lights.—The head-lamps of cars or acetylene flares at night not only act by producing a transient blinding after-image through excess of light, but also by throwing this with enormous effect on a dark-adapted, highly sensitive eye. The gas flame, or electric filament, intensely glaring at night, may shine almost unobserved by the eye adapted for daylight. A match struck in the dark causes a momentary but almost painful dazzling glare. The object looked at should be about the brightest in the field, with a brighter object the eye tends to turn to it, so that here at once is a cause of discomfort.

The eye is adapted to the general average, so that to an audience sitting on a sunny day in a large room with shaded windows at one end behind the platform, on a small part of a window being uncovered, the glare was unendurable. As the whole window was opened up, and then a couple of neighbouring windows, although the lighting became hundreds of times stronger, it was more uniform,

eyes became adapted ; the room seemed brilliantly lighted without glare. Temporary glare may thus occur in an eye adapted for low illumination, and this will be likely to happen in a poorly lighted room which has streaks or reflections of bright light in it. Badly set prism glass, or plate-glass with designs cut in it if set low in a window, are likely to set up nearly horizontal streaks of light with such glaring effect.

Sunshine is, educationally, very objectionable in a class-room. Mere superstition credits it with strange powers over germs which it cannot reach or touch, and the window glass deprives it of its metabolic violet rays. A western sun, low on the horizon, shining into a class-room can reduce the average visual acuity. The old-fashioned ribbed glass formerly popular in ground-floor windows, especially in voluntary schools, had similar effects.

It is adaptation which explains the great differences between the intensity of natural and artificial lighting required. With fairly uniform distribution of light this adaptation scarcely causes any trouble, but with masses of brightness and shadow, glare may be felt. A blackboard set against a white wall may be troublesome. An actual instance occurred in a class-room with good lighting, measured on an average day as about 2 to 6 foot-candles on the desks, but the play-shed complained of as too dark for use at the same time was measured as from 6 to 12 candles, the only differences being adaptation of eye to indoors and outdoors respectively. The American Standard Code puts the range of maximum on school desks as not to exceed four times the minimum illumination.

Unfocussed Light as a Source of Glare.—Glare from unfocussed light veiling the focussed images on the retina chiefly arises from shiny surfaces, reflecting diffused images of the sources of light into the eye. The eye is accommodated for the object looked at, and this unfocussed light comes as from an image far behind the reflecting surface of the object. Even if these unfocussed sources are not considered as images they are sidelights entering the eye nearly in the line of vision, and setting up a veiling haze. The glaring effect they produce depends upon the amount of this light entering the eye compared with the amount from the object forming the image. In daylight, a brightly lighted window in a dark room may be glaring and pasting tissue paper over the window, partly by diffusing the light, and partly by permitting more dark adaptation, may make the room appear brighter. For the same reason indirect illumination, owing to the higher light adaptation of the eye, is less efficient visually, with equal amounts of light, than other well-planned systems of direct or half-direct lighting.

In rooms, especially if not well lighted, the moderately adapted eye may resent shiny surfaces of walls or desk tops, and if there are few bright sources of light high in the room the reflections from shiny

objects may exert a kind of distracting effect, especially if attention is beginning to flag.

Shiny Surfaces as a Cause of Glare.—All school-room surfaces, furniture or walls are therefore recommended to avoid bright varnish or smooth gloss, and to have dull or non-reflective finish. The essential feature of glare in school, however, is that too often the total light tends to minimal rather than excessive amounts, and that, as in the case of the railway clock (p. 521), the straining after clear images by ocular fixation intensifies any glaring effect. This is more marked in certain cases; the presbyope teacher, whose glasses are not strong enough, and whose accommodation is sinking nearly to the limit of usefulness, constantly complains of glare by artificial light.

More important, however, and probably part of a vicious circle, is the effect on the young student, who is habitually using the eyes in an intensive way, far beyond what any generations before have done. The spasm of overworked ciliary muscles and fatigue of their nerve centres, and possibly allied conditions of structural irritation with nutritive changes, especially in early myopia, have made the eye sensitive of glare in any effort of exact work, although he no longer meets the jumping gas flame which made his parents seek relief with a colza lamp. The eye-strain due to glare becomes increasingly obtrusive after the twelfth year. It is reading, writing, and figuring that demand accurate images, although even here the scholar works without the proof-reader's eye for detail. In these tasks, especially, is glare evident; it becomes insistent and is distracting to attention, seriously hindering the efficiency of educational aims.

Artificial lights may be very troublesome, and as the shiny reflection glares proportionately to the intrinsic brilliancy of the source of light, it is again a reason for insisting that no naked filament, mantle, or flame should be permitted, nor any visible source of light with greater intrinsic brilliancy than 3 candle-power per square inch.

Eye-strain.—The eye-strain of defective lighting results from either glare or poor lighting, and is chiefly due to the attempt at steady fixation. It is scarcely realizable what microscopic minuteness of adjustment is possible, at great nervous expense, in adjusting the dozen different muscles of the eyeballs and maintaining the accurate effort.

Dr. W. B. Lancaster (*New York Med. Journ.*, August 29, 1914), in regard to the usual resolving power of the eyes, taken for two black lines on white as 1 minute, states that, by stereoscopic tests it may be reduced to 3 seconds, certainly under 12 seconds, and is $\frac{1}{5}$ to $\frac{1}{24}$, the standard taken as normal acuity, so that making all allowances we fix to within a few thousands of a millimetre. Usually with

sufficient lighting, there is no exactness in work, a glance at one or two prominent indications, and the picture is filled in mentally, with, it is true, many mistakes, up to 30 per cent. the kinema psychologists say, in the apperception of things seen. Where there is dim light or glare and the eye makes its utmost efforts to see, the above finer adjustments are possible, but can only be maintained at the expense of hyperæmia, and fatigue of eye-strain. It is this kind of work from which the early myope requires especial protection.

The resolving power of the normal eye approaches so nearly to the theoretical limit that, as Lord Rayleigh noted (*Nature*, 1885. 386), there is no room for the savage eye to be much superior as an optical instrument to that of civilized man.

Blackboards.—The next noticeable source of glare in teaching is the blackboard. Blackboard glare is almost certain to affect a considerable percentage of students from their relative position in class. A black and matt dull surface is worth maintaining by weekly attention.

A good position of board avoids reflection of lamps, windows, or bright walls in the faces of the pupils ; by suitable tilting, these images can be thrown in other directions harmlessly. With artificial lighting, the yellow colour requires good contrast to be maintained between the colour of chalks and board. The written figure should be brightly lighted from above so that any regular reflections fall towards the floor. A high accessory lamp near the board, and shaded completely from the pupils, aids illumination, and lessens relative degree of glare.

Glare from paper is the commonest source of trouble felt by the student, even with moderate lighting. Although understanding of glaring paper helps many school problems, it has had little attention beyond the condemnation of glossy surfaces, until well worked out by Luckiesh (*Buffalo Congress*, 1913, vol. v. 365). The rays of light from an object which fall on a mirror are regularly reflected, that is they pass off in such a way that a perpendicular to the surface of the mirror where each ray is reflected is in the same plane and makes the same angle with incident and reflected ray. The light falling on other flat surfaces is partly reflected in this way (regular or specular reflection), so that it appears to emerge from a point behind the surface corresponding to the position of the source or object in front. Another part of the light, however, is reflected irregularly and goes off in all directions, so that it appears to come from the surface itself, and not from any object behind ; it partly penetrates the surface, and is the light by which the surface is characterized and recognized. This irregular reflection or scattering of light takes place in all directions, but as a rule there is excess nearly in the same plane as the incident light.

Trotter devised an instrument for the British Association Committee (*Report*, 1915) for determining glare from all ordinary materials without metallic gloss. It depends on balancing the ratios of diffused and specular reflected light. Another instrument, the glarimeter of Ingersoll (*The Lighting Journal*, April 1919), does not actually measure these values, but by measuring the proportion of light polarized when reflected from paper at 57·5° gives a relative value for the glaring light (*Illuminating Engineer*, February 1915).

For school purposes of reading and writing, all the contrast possible between the black of the letters and the white of the paper is required.

The surface brightness of paper should be a hundred times that of ink. Only the irregularly reflected light which shews up the texture of the paper and colour of the ink is wanted by the eye. The eye is accommodated to the focus of this paper and ink. The amount of regular reflection from the surface tends to form an image of the source of light which appears to be behind the surface, and for which the eye is not accommodated, so that diffusion circles of unfocussed light are formed on the retina, blurring and interfering with, veiling and reducing contrast in the focussed image of paper and print, and causing glare from subconscious efforts to compensate or correct the faults in the image.

The proportion of this regular reflection must be kept as low as possible. By pressure of hard types it is possible for black printed letters to have a smoother surface than the white paper, so that beyond a certain angle of incidence of light illuminating the surface, the letters are as bright or brighter than the paper, and become invisible.

The ratio between the reflected (glaring) and scattered light gets more the greater the angle of incidence, so that obliquely placed paper is troublesome.

Conditions of glare in low degrees are accentuated by ocular sensitiveness due to malnutrition of the nervous elements of the retina, as in early myopia, spasm, migraine, neurasthenia, and chronic fatigue from excessive eye work. Beyond this the position of the eye must not fall within the region of regular reflection, for which reason commonly in olden time, as still in churches, reading was done standing at a desk looking down at the book placed at such an angle that any regular reflection tends to fall below the chin.

When light, book, and eye are not approximately in the same plane, glare does not predominate, as, for instance, with the light coming over the shoulder. It is not only actual lights *en face*, as when a student sits at home at a centre table with a light in the middle of the room, but also bright reflected images which are equal to sources of light.

As the surface brightness of the paper and print varies inversely as the square of the distance from the source of light, whilst the glaring reflection remains about a constant brightness, although the glaring image decreases in size or area the brightness of the print increases, and the relative contrast of the glare gets less as it is brought nearer to the source of light. Where no regular image tends to be formed as with indirect lighting, for instance, glare is absent. Indirect lighting, however, has many disadvantages for school-work, and semi-direct, with large sources of light of a brilliancy of the same order as the neighbouring ceiling, appears best for school use, and has little tendency to produce after-images.

CHAPTER XXIV

SUBNORMAL VISION

Subnormal Vision.—Many cases require special educational provision beyond the ordinary elementary school routine, purely on account of their visual defects.

They may be classified—

1. Those who can continue in the ordinary school, with certain restrictions (7 or 8 per cent. of school children).
2. Those who should be educated, with totally different ideals to the ordinary school curriculum, in sight-saving classes (including high myopes) (at least 1 per cent. of school children).
3. Those considered educationally blind (about 0·15 per cent. of roll).

There are children with slight defect that may diminish visual acuity, or may get worse with even ordinary school strain. With these ought to be included all cases of spasm and slight myopia, which would raise the numbers to 10 per cent. of all children. In practice not half this number are ever noticed, and not one-tenth placed under restrictions. The children considered are only about the worst tenth who have been examined for other visual treatment, and not deemed bad enough or there has not been sufficient provision; at the same time the doctor's conscience will not allow them to return to the ordinary school, so a salve is applied by a proviso for special treatment, of which, from ignorance on the part of the teachers and taught, no further notice is often taken.

Teachers of secondary schools are particularly hard in many of these cases, even refusing admission to such pupils, forgetting that the school purpose is individual education and not the mere passing of examinations.

What particular standard in the curriculum a pupil attains does not matter so long as education goes on reasonably, and to the full limits. Further, there are many pupils in every secondary school far below the mental average of these eye cases, even allowing for their handicap, whom there would be no idea of refusing. In this matter many teachers require to be taught, and no teacher should be allowed to refuse a child on account of such visual restrictions.

The instructions drawn up by Bishop Harman regarding these children, to whom the educational wind has to be tempered, should

be printed for general use as "Children for Easy Treatment" and the severer cases, "Children for Oral Teaching only."

Children recommended for "Easy Treatment."—These children usually suffer from a defect of one eye only or they have defective vision in both eyes of a moderate degree. With reasonable care school-work should not cause strain of the eyes or entail the risk of exaggeration of their visual defect. These children should sit in the front row of the class, sit upright and not be allowed to stoop over any literary work allowed them. Girls must do no sewing, but may learn knitting, provided it be taught by touch and not by sight. Boys and girls should be prohibited the use of books with small print or writing of any sort other than a bold, large-lettered hand. They should not join in exercises that involve the reading or writing of masses of numerals or geometrical figures. They may read or write in large type preferably for periods not exceeding 20 minutes without a break. They should not be allowed to stoop over their work, and, if it be possible, the writing should be done free-arm fashion on a blackboard or millboard set up on the desk.

So far as school arrangements allow they should attend all the object lessons, demonstrations, and oral lessons that are given in the school.

Drill, dancing, games of all kinds may be freely indulged in.

Home lessons of any sort should be prohibited.

Children recommended for "Oral Teaching Only."—These children suffer from some serious defect of vision such as gradually increasing short sight. When no place can be found for them in a special class they are admitted to the elementary school with a view to their gaining the educational advantage of school discipline and such general knowledge as can be given them in the oral lessons of the classes.

The use of books, pens, paper, pencils, and slates of any kind and for any purpose is to be prohibited, and the child should be reminded at intervals by the teacher in a friendly chat that the prohibition is for his or her own benefit, and that they must do at home what they are trained to do at school.

If the class arrangements permit they may be allowed to write or draw on the blackboard in large characters free-arm fashion.

If a girl shews aptitude for handwork she may learn knitting by touch, but not by sight. Similarly a boy may do the larger kinds of carpentry, but he must not use the rule or draw measured plans.

For the most part these children may drill and dance, but in the case of high myopia they should be warned against using gymnastic apparatus or dumb-bells, for example, in connection with the Children's Happy Evenings Association. They should be cautious in the playground games.

The earlier reports of the London Education Service contain many references to the needs of children visually unfit for the ordinary school, and in 1908 a class was opened for "helping lame dogs over stiles," as Harman termed it. Having originated out of the discussion of high myopia, these classes or schools have come to be termed myope schools.

The official term, "partially blind children," is particularly unfortunate for the majority. Sight-saving classes is a much better indication of their *raison d'être* than any other term. In England, myope school seems to be generally accepted.

Their curriculum was oral teaching, manual work, and literary

work. Books, paper, pencils, or pens are not to be seen there. No books are permissible. The children should learn the minimum of reading from wall sheets, and they must be instructed, that until they are full grown, reading is for them a vice. There is a band of blackboard run round the room on which the children can chalk at arm's length. They also have special desks devised by Bishop Harman.

The Ideal of the Myope and Sight-saving Class.—This is quite different from the literary ideal of most school-work. For the majority of these children it would possibly be an advantage that they should not learn to read or write beyond the merest rudiments. All who have to do with these classes, particularly Americans, should remember the dictum of the great educational administrator, Horace Mann, "Reading and writing are not education." On the other hand, the children should be fully instructed in all that they can learn about ocular hygiene and good practices.

Owing to the difficulties in getting parents, teachers, and others to consent to children attending these classes, a useful sheet of information has been compiled for their information, briefly stating that to save children with short sight from eye-strain these classes have been instituted. The conditions of the class are set out—

1. For all lessons that can be learned by listening to the teacher, the children in the myopic class go into the ordinary school.

2. Lessons that need reading or writing are given in the myope class. Instead of using books, pens, and paper, each child has a large blackboard on which it writes with chalk just as the teacher does.

3. In the myope class a speciality is made of handicraft—various forms of carpentry, bent ironwork, model making, printing from blocks, and drawing. The children enjoy the work immensely and the instruction is most profitable.

4. The children learn to dance and drill, and for these lessons most of them are able to join in with the ordinary children.

You are particularly asked to take your share in carrying out the scheme for the protection of your child's eyes. Get the little one interested in games and outdoor play. Do not let it read or write.

These circulars should be amplified and illustrated, not only to give information, but also to appeal to reason, as in spite of these there is continual trouble. For instance, a girl of 11 is seen as a scholarship candidate with rapidly advancing myopia of 7 D. When she was recommended for the sight-saving class, her father "most emphatically declines to allow it."

He objects to the class of children, says education is practically nil, and that her chances of a secondary education and the future will be spoilt. He has already had another girl there.

The girl's head mistress of the County Secondary School writes: "We have never had the test yet that a fee-paying pupil would have to be withdrawn for defective eyesight, although there are

cases in the school." The doctor who certifies these cases must be prepared to adhere to his decision.

It is obvious that if these classes are to fulfil their function, a curriculum will have to be drawn up entirely different from that of the ordinary school, bad as this is from the visual point of view. The teachers, too, must be trained and practised to this new ideal, so that the old routine may be completely cut out.

The attainment of a myopic class cannot be judged by the standard of the ordinary elementary school.

The conditions to be worked to are practically all requirements to avoid congestion and strain of the eyes. There should be no near work making demands on convergence of the eyes. The arm's length is the limit of nearness. There should be no protracted work, nor work involving stooping or bending over of the head. Fine objects or close attention to limits should be avoided. Wherever possible the kinæsthetic sense should replace visual work.

There is no objection, for instance, to children writing with pen and ink provided the pen carries a shield which overlaps the writing point an inch in all directions. Writing will then be learnt first with chalk on the blackboard, then by kinæsthetic sense with the pen, and it is probable that such writing will be more legible and better formed than if written visually.

There should, again, never be guiding lines on blackboard or paper, although one sees them in use, as in the published pictures of a Sheffield myopic class.

Script writing is the best for these classes, being more easily learned muscularly, and more legible. Writing as a muscular exercise for the fine finger muscles is of the first importance educationally, but eliminate vision as far as possible.

Typewriters are found useful in the American Conservation of Vision Classes. They should be introduced, after about nine years of age, in the myope school curriculum. Unseen keyboard work is to be set up as the aim to attain.

Arithmetic may be done mentally for all practical purposes. One wonders how the Romans did their engineering calculations, or extracted square roots with their cumbrous notation. Most of their arithmetical work must have been mental.

Good lighting is demanded in every part of the room. It is useless trying to relieve strain on the eye from small objects if it is replaced by a strain due to insufficient light. The requirements for lighting must be carried out fully. The minimum permissible desk illumination must be 7 foot-candles. In American schools this demand varies from 7 to 10. If the minimum of 7 is obtained, the rest of the room should be sufficiently well illuminated to preclude any severe strain.

It is an advantage to have these classes small enough for indi-

vidual tuition. The maximum roll permissible is twenty, although since the War the Board of Education has permitted twenty-five, this number is excessive for good work.

Children should join as soon as possible, the age of 7 or 8 ought to have found the most serious ones out. About a third of the time can be profitably employed in the ordinary school. Too much can be made of the idea that the children gain socially or in public spirit from these lessons, and it is just possible that a myope from a teaching point of view may be supposed to be wasting time. Myopic pupils have been given ordinary books to read whilst the other children were being given a geography lesson.

From the standpoint of pure technique and classification myope schools might be recommended with a different educational range, and for ten times the number of children, whose eyes, selected by tests yet to be elaborated, were known to be of defective resisting power during the period of growth.

At present the small sight-saving class is the only one practicable save in densely populated districts.

Whatever administrative method be followed, the work of the sight-saving class must be directed by a specially trained teacher, free from control of any untrained person, and especially from its functions being sacrificed to rule of thumb ideals of the ordinary school head or inspector. Unfortunately, most teachers in myope schools are not specially trained, and still make many mistakes in treatment of pupils. At present from want of grasp of the new ideals these classes have not reached their possibilities, and in some cases children are marking time educationally for their last year or two.

In 1923 the Board of Education wisely decided that myope schools should not be administered under the head teacher of an adjoining elementary school, and that they should on no account be connected with blind institutions, even by proximity.

Harman, who has built up these classes in London, describes details in several papers (*B.M.J.*, 1910. ii. 1320, and *S.H.*, 1919. i.). *The Educationally Blind Child*, by MacGillvray, describes Dundee classes (*S.H.*) An American account with illustrations unwittingly unhygienic by our canons is given (*The Child*, 1923).

Classes were started in Germany—*Schwachsichtige Klassen*—in Strassburg, Mühlhausen, and Dortmund, in 1911, where children are said to attain the same standard educationally as in the ordinary school. They are allowed writing for not more than 15-minute lessons.

Copenhagen started classes for children with poor vision, with acuity between $\frac{6}{24}$ and $\frac{6}{60}$. Pupils do not appear to be selected for myopia. Reading is done by using an ingenious *loupe à lentille*, a plano cylinder about 5 cm. in length, tilted a little in its frame, it magnifies the line of print two or three times with a little

distortion, and while useful for bad vision, as for instance old corneal opacities, would be straining and harmful for myopes.

Before the War, Cleveland, in America, initiated Conservation of Vision classes, a better descriptive term than myopic. The standards adopted are myopia of 8 D. or more ; maculæ or leucoma, with vision less than $\frac{6}{15}$; and hyperopes of 8 D. with asthenopia ; congenital cataracts cases operated on with vision with glasses $\frac{6}{15}$ or less ; children, too, whose vision is $\frac{6}{36}$ or less, and children with interstitial keratitis, uveal or corneal disease under treatment and temporarily withdrawn from the ordinary school.

Text-books are allowed, printed in clear-faced, heavy 36-point type on unglazed paper of a buff tint. There are ten children to a leader. Boston started classes about the same time, and was quickly followed by Ohio, Illinois, New York, and Michigan. Now such classes are general. After eight years Ohio announced that where the school inspection includes examination of the eyes by a specialist there is one sight-saving pupil to 1600 of the school population, elsewhere the proportion is 1 to 250, and where adequate treatment is provided for conservation of vision 33 per cent. of the children return to the regular classes.

About two-thirds of the pupils attending in London are myopes, and perhaps a quarter have superficial or interstitial keratitis, the remainder being chiefly various congenital defects. In thirteen such classes, there were 226 high myopes, 73 with keratitis of different forms, and 58 with various congenital and other rare affections. From these figures it will be seen that " myope class " as an exact term is a misnomer for these sight-saving classes.

Possibly these schools might be more successful in populous districts if the children were scheduled into A, arrested cases, and P, progressive cases.

The A children could be allowed all activities which they could see, all occupations they could handle, and are simply in these classes to get better oral training than they could have in the ordinary schools, where reading and writing would be wasted on them, if not impossible. These cases, however, are comparatively few, but the knowledge of such cases might lighten the teachers' work.

They would be old cases of ophthalmia neonatorum, cases with corneal opacities, some with nystagmus, disseminated choroiditis, congenital defects like dislocated lenses, colobomata, aniridia, albinos, and perhaps a few others. They might be decorated by a blue button in school, and in any case would not reach 20 per cent. of all.

Four-fifths at least of the children will belong to the P category, whose eyes with active disease must be protected, during the growing period. They have to follow the strictest sight-saving regime, doing no continuous, accurate, or fine eye-work, and the avoidance

of all such work in or out of school should be inculcated till it becomes a regular habit of their lives. They are allowed to read print in the London Schools in books made by the older scholars with india-rubber types, the face of which for short, small letters is 1·5 cm. high, and 1·3 cm. wide, and for capitals, 2 cm. This corresponds to V.A. $= \frac{6}{14}$.

The difficulty of keeping the eye-work distance at 30 cm. is considerable, and as Dr. Hay has pointed out in Sheffield, the children of medium myopia actually get better visual acuity at from one-third to one-half this distance, so that the remedy has to be avoidance of any finely textured work.

One hears a great deal of the dangers of high myope cases from hæmorrhage or detachment. These risks are mostly after the period of growth.

The writer remembers a nineteen-year-old girl candidate for the teaching profession whom he excluded in the middle of her training. She was, within four months after exclusion, blinded by hæmorrhage at one macula, then at the other, but that is the only case he has met in so young a person. Football and violent games are likewise forbidden, from fear of detachment, but here again he has only once known detachment of the retina occur in this way in a young myope.

Guides.—For either blind or partially blind, including the pupils of sight-saving classes, it may be expedient to recommend, and the Local Education Authorities have power to provide, guides or conveyances to and from school. The duty of attendance, however, is imposed upon the parents by the Education Act, and the local Education Authority are not compelled to make such provisions, nor are they in any way liable or responsible for accident or damage to children on their way to or from school without guides.

CHAPTER XXV

THE BLIND

Blind.—The majority of the blind will always be dependent, but much can be done to help them by education. The first requirement is a definition of what blindness is.

The ophthalmologist in his consulting-room classifies blind—

1. *Blind.*
   - (i) Those with no perception of light.
   - (ii) Those who cannot differentiate fingers but who see moving shadows and perceive light.
   - (iii) Those who differentiate fingers when nearer than a yard.
2. *Semi-blind.*
   - (i) Those who differentiate fingers more than a yard away.
   - (ii) Those who can make out $\frac{6}{60}$ type.

The person is blind whose vision is no use for the practical purpose of life.

Trousseau called blindness inability to count fingers at a metre, and MacCallan has adopted that for his Egyptian work.

Fortunately at the very outset for school and educational purposes, Section 15 of the Elementary Education (Blind and Deaf) Act, 1893, gave a very elastic definition. "The expression 'Blind' means too blind to be able to read the ordinary school books used by children." It was this definition, adhered to in Section 69 of the Education Act of 1921, which first made the special classes for conservation of vision possible by claiming for them at that time grant as Blind Schools, and in many returns these semi-blind are included as blind. Partially blind, as applied to the class of children admitted to the myope schools, has already been noted as an ill-advised term.

Statistics of blindness are extremely variable with time and place.

The Census of 1911 returned 33,965 persons blind in England and Wales, of whom 2184 were below 15 years of age. All the blind for school purposes would not be included.

The Committee appointed in 1920 reported 8 per cent. of the blind as below 16 years old. In England and Wales, under the Blind Act, 1920, there were reported as blind in March 1921, 0–5 years old, 302; 5–16 years, 2563; 16 and upwards, 52,029.

A reduction in blindness shews in the United States of America, from 57,272 in the Census of 1910, to 52,617 in that of 1920; males predominated by 3 to 2.

America is hopeful, with the reduction in ophthalmia neonatorum now going on in the large cities ; for instance, Buffalo, with nearly a million population, only had two cases of this disease in 1920, and New York is equally successful (p. 536).

Smallpox, too, has ceased to produce its crop of dire effects in blinding. Bishop Harman has analysed the causes of 4288 cases of scholars' blindness (*B.M.J.*, ii. 1921). Of infants, half are due to ophthalmia neonatorum, and one-third to congenital defects. He summarizes the school cases as follows, assigning about one-fifth to gonorrhœa and about one-third to syphilis as factors.

Table 79.

Disease.	Number.	Percentages.		Gonorrhœa.	Syphilis.	Uncertain Syphilis.
		1920.	1913.			
Ophthalmia neonatorum (all) ..	367	19·79	24·17	367	—	—
Purulent conjunctivitis of later years (all)	90	4·85	4·27	2	—	—
Phlyctenular keratitis (bad) ..	66	3·56	3·45	—	—	—
Interstitial keratitis (all) ..	399	21·51	19·18	—	359	24
Iridocyclitis (all)	14	0·76	0·54	—	7	5
Optic atrophy, with or without disseminated choroiditis (all)	349	18·81	20·18	—	212	19
Buphthalmia (all)	17	0·92	1·54	—	5	2
Sympathetic (all)	29	1·56	1·45	—	—	—
Macular defects (all with congenital nystagmus (bad)	55	2·91	2·09	—	5	—
Retinitis pigmentosa (all) ..	39	2·10	1·81	—	8	—
Detached retina (both)	2	0·10	—	—	—	—
Albinism (bad)	36	1·94	2·27	—	2	—
Lens defects (all)	248	13·37	12·90	—	25	—
Other congenital defects ..	91	4·90	4·81	—	—	—
Bad myopia	54	2·91	1·18	—	—	—
Totals	1855	100·00	—	369	618	50
Percentages	—	—	—	19·89	33·31	2·69

In the first medical survey which the writer made of the London Blind Schools in 1903, 42 per cent. were assigned to ophthalmia neonatorum, but as there were many others whose troubles were probably due to this, but of whom there was no satisfactory history, it was felt that an estimate of 50 per cent. would not be exaggerated. The number is slowly falling. In this respect large American cities can set us an example. The cases in places like London or Manchester should be one-tenth of their present numbers.

Ophthalmia neonatorum is also the cause of much visual deterioration from corneal scarring in children not blinded.

The next large group is interstitial keratitis, many of these cases come on during school life, although the cause is congenital, and some are also associated with deafness. Much can usually be done for vision by early and energetic treatment, but the hearing is rarely bettered, and in bad cases the individual is wrecked, although not totally blind or totally deaf. The prevention of syphilis and its effects in this generation would clear the schools of this group in a decade.

As to the frequency of these specific complications, Harman, in 600 cases of children blinded from syphilitic causes, who had been under care on an average 6 years, found 398 with interstitial keratitis and 229 with disseminated choroiditis.

The 398 interstitial cases shewed Hutchinson teeth, 265; iritis, 128; deafness, 63; scarred mouth, 61. With the 229 choroiditis cases there was optic atrophy 117; Hutchinson teeth, 7; and deafness, 51.

Heredity in blindness is not so obvious as among the deaf. Many congenital cases are, however, hereditary. Congenital cataract occurs in over 50 per cent. of children born to parents with congenital cataract (Norton, *Journ. of Oph. O. and Laryng.*, November 1914), and 50 per cent. of children of parents with retinitis pigmentosa have the same defect.

One of the first ophthalmic cases which impressed the writer was a semi-blind woman with microphthalmos, whose six children were of the same type. Ash (*Brit. Med. Journ.*, April 8, 1922) mentions a family with hereditary microphthalmos affecting the males.

A blind boy from cataract, whose notes are at hand, has his father, three unmarried aunts, and grandfather in similar condition.

Hereditary optic atrophy exists in some families.

The Committee on Hereditary Blindness (U.S.A., 1924) report that eight of the distinctly hereditary defects which they investigated are likely to cause blindness either directly or indirectly.

About 8 to 10 per cent. of the blind are hereditary. There is an extensive bibliography of 800 references on hereditary blindness published as a bulletin by the Eugenics Record Office of the Carnegie Institute.

Lastly, about 3 to 4 per cent. of blind children are due to phlyctenular keratitis. Every one of these cases is preventible by good hygiene.

A congenitally blind person may be a social danger for the future, and, if with heredity of blindness, should marry no other blind person, if they marry at all. Diminution of pension might easily be used for eugenic purposes to penalize blind persons' improper marriage with each other, and if the blind children of blind persons were only allowed much reduced pensions.

A certain number of the blind have had an eyeball removed. Sympathetic blindness after an injury does not occur where the eyeball is removed early. The risk, then, is infinitely small, whereas attempts to save a damaged eye have often resulted in the good eye being left worse than the other, or even being lost from sympathetic inflammation. Although retention is much safer than formerly, in the slightest doubt about a child never hesitate to advise speedy removal of an eye badly wounded in the so-called dangerous zone.

There are other conditions, such as anterior staphyloma after corneal injuries or ulceration, or buphthalmos, where the globe is removed with advantage. Hygiene of the empty socket, whether a shell be worn or not, must be insisted on, or many of the children will get chronic mucopurulent conditions set up. For general purposes the use of boracic lotion or weak sublimate solution is sufficient. The last irritates in some cases, and is poisonous, so is, perhaps, better not used generally with children.

The following advice in the form of a circular is often of use for the parents of blind children, who have had the globe removed—

How to Take Care of "Artificial Eyes."

The socket of the eye should be syringed gently night and morning with some warm boric acid lotion. The strength of this should be about a teaspoonful of the powder to a pint of water.

Before going to bed, the artificial eye should be taken out, wiped with a soft cloth, and placed in a glass with boric lotion. It is useful to keep a piece of cotton-wool or clean rag at the bottom of the glass to prevent the eye being scratched.

The eye should be examined by the teacher or optician every four to six months to see that the edges have not become roughened, as the irritation caused from rough edges leads to shrinkage of the socket, so that ultimately it is impossible to wear an eye.

Unless watched, many blind children develop habits of picking and fingering their eyes, nose, and mouth, or nail-biting; habits which must be prevented. The wearing of dark shades as spectacles is a great advantage, and where there are empty sockets, or irritable conjunctivæ, the shades protect from dust and injury. For outdoor wear triplex glass is advisable for children's shades.

Physique.—The general physique of blind pupils requires constant education. Their round shoulders and slack attitudes are of greater mental import than postures in the seeing. The uneducated blind child tends to sit huddled up, or swaying rhythmically to and fro. This is apart from the head movements sometimes seen in children with perception of light, but with lost eyes and nystagmus, a condition which remains.

All blind children should have much exercise in balancing by walking the plank at first on the flat, then on its edge, till they gain complete confidence and good balance. This exercise freely prac-

tised seems the most important of physical exercises for corrective purposes in blind children.

A first-class posture is wanted either sitting or standing. It is the greatest asset the school can give. The chin should be kept in, the head so that the collar stud can be felt behind the neck. Walking exercise to get a good gait without bent knees or flexed body, and with firmly planted feet without a shuffle in movement. The toes must not be turned out in walking. The timid cautious feeling or creeping movements in a room requires replacing by firm, unhesitating steps. Plenty of marching, running, skipping, and dancing to music is advisable, with jumping exercises to give confidence. There should be free standing Swedish work to get good vital capacity. Insufficiency of circulation and respiration is too common still, and there is a general want of tone in such children. Swimming and roller skating are good diversions if provision can be found for them. The obese, flabby blind person is a well-known example of what to avoid.

The physical and moral effects of games which involve effort both muscular and mental are to be used educationally as well as for recreation in pushing and pulling, hopping and skipping games, "follow my leader." All varieties of blind will benefit by these exercises.

The mentality of the blind has to be remembered. Accidental causes, such as ophthalmia neonatorum may have damaged perfectly normal children, whereas the poison of syphilis in another group may have produced all varieties of general defect in other tissues and even in the brain. Again, cases where there are obvious degenerative qualities, and where malformed eyes may be among the stigmata, may present any condition from almost normal mentality to feeble-mindedness or imbecility. Infants with congenital cataract who do not attempt to follow a lighted candle with their eyes are generally feeble-minded and not worth operating on, the fundus often being damaged.

The child blind from myopic conditions as often as not presents a superior mentality. So that all qualities have to be provided for educationally.

The Consultative Committee on the welfare of the Blind in their first Report in 1919 set down 20 per cent. as mentally feeble, epileptic, or with serious nervous debility. In March 1921 there were 17,229 blind reported as unemployable out of a total of 34,894, roughly half. The number of defective blind, all ages, reported was : mentally defective, 1383 ; physically defective, 3596 ; deaf, 1368 ; and combinations of these three classes, 709.

Hearing is generally good with the blind, and many of them have considerable sense of rhythm and music. The tactile sense is supposed to be extraordinarily acute, but almost the first school

observations the writer made shewed him that the threshold of touch in the fingers of blind children was no greater than in intelligent seeing children. His æsthesiometric method had not the delicacy introduced since the work of Griesbach, but it was perfectly definite. It is the intellectual apperception of things felt which becomes so acute in the trained blind, not the mere discrimination of one or two points. The threshold is very much affected by the circulation, and cold, dead fingers cannot perceive as well as those with a fair surface temperature, for this reason great care must be taken in winter to keep rooms not below 62° F.

Some of the blind are said to possess a sixth sense in what is called facial perception. This is the power of distinguishing objects, doors, window-posts, and so on, on the level of their face, and within 2 or 3 yards so that they can avoid them. It seems to exist in some cases. This sense is said to be temporarily lost on painting the face with cocaine solution. It has been attributed to differences of temperature, to sensation of air pressure or current, or even to reflections of sounds, but has never had satisfactory explanation, and is not possessed by all. It seems almost certainly due to subconscious estimations of sound, echoes, and variation of tone, although exceedingly difficult to prove.

An intelligent blind person probably suffers a good deal from want of education. The young blind should mix with seeing persons as much as possible. Wholly blind schools are an administrative convenience, but are educationally incomplete. Whilst the deaf infant could not be got into a special deaf school too early, it is quite otherwise with the blind, and some of the best blind people argue that their place should have been the ordinary school, with special lessons in Braille.

The school must teach these children self-confidence and self-respect. They should be made part of the rest of the community, although the majority are bound to be dependents, but State pensions or grants will help to maintain respect. Their useful employments in later life are very limited, only about one-third are real wage-earners. In two of the best schools for elder children later enquiries shewed 42·2 per cent. of boys and 50 per cent. of girls earning satisfactorily, most of the girls being employed in a knitting industry.

Reading, writing, and arithmetic mean much to them. Many are verbalists, pouring forth fluent statements about nothing.

Ancient attempts at finger-print were made before a Dane, W. Moon, himself becoming blind, used embossed Roman types. Discarding letters, difficult or complicated, for other forms, he came down to nine signs. In this he had the Scriptures printed in many languages, so that his method became extensively used at home, and even in the East. It has now been almost superseded by Braille. In this method, invented about the beginning of last century in

France, a series of raised points constitute an alphabet, and by using a special frame the pupils can readily emboss the same points to write.

A further variety of Braille, New York Point, is used extensively in America, but looking to the cost of production there should, if possible, be a uniform system of point and writing everywhere. Here the League of Nations is wanted.

Whilst the Braille type and frames enable pupils to read easily, and to write in the same way, some are able to learn ordinary typewriting, but they are exceptions who can turn it to much practical use. Children love to read Braille, and sometimes in institutions smuggle books into bed to read surreptitiously at night under the blankets.

Although the blind do not see, they apperceive. Touch, taste, smell, sound, the muscular sense, all build up the mental image, so that there are blind persons who go to a kinema entertainment and enjoy it.

It is said that children blinded before 5 to 7 years of age never dream of colours, whereas, when blinded after this age colours are often seen in dreams. The teachers obviously have tasks of supervision over children which render blind persons unsuitable. Although the Committee on Blind recommended blind teachers, it was presumably for service in the residental institutions, which they also recommended.

The blind schools are under the ordinary medical inspection of schools as regards general health and physique. Posture requires particular attention, and each pupil should also at least once a year have an expert ophthalmic examination to note changes or conditions requiring special care.

For some of the handwork tasks, and for the older pupils, a blind teacher may have an understanding and sympathy appreciated by the pupils beyond the average sighted teacher, but such a blind teacher should never be in entire charge ; and if any are permitted, no day school should have more than one blind teacher on the staff. The teacher who is merely certificated and pays little regard to hygiene or posture is worse than a blind teacher for the work.

In testing the mental capacity of the blind, the usual tests are not all available. The Binet-Simon Scale has been worked out in an adaptation of the Yerkes Point Scale modified by Dr. T. H. Haines in *The Mental Measurement of the Blind* (Psycholog. Monographs, Princetown, N.J., 1916). In this country Dr. W. B. Drummond found (*Edin. Med. Journ.*, 1920) that after the age of 9 the teacher's estimate of capacity agreed very closely with point scale determinations. Definite mental assessment is desirable at as early an age as possible. In the Ohio State school (1915) the examination of 224 pupils by Haines tests resulted in 13 being

picked out as mentally insufficient for training in that school (*Journ. of Ed. Psych.*, March 1916. 143).

Many of the blind are timid, they trust so much to others that they shirk responsibility. Blind teachers have seemed to the writer kind and gentle, but shockingly ineffective in regard to the matters which he regarded as vital in a mixed school.

Mental orientation of the blind is easily upset, and their minds equally disturbed. They are cut off from sights around and fill in the gaps with fantasies and introspection. There is a want of initiative and self-reliance for which the shocks and surprises of daily life in the ordinary community is an effective education in the young.

From the blind child's side the public elementary school would be the best place in a country district, but they are inconvenient in town and numerous enough to separate. They also require the special instruction in Braille. But even when gathered into blind schools these would be better attached to the ordinary school.

The Residential Institution is only truly suitable for the mentally defective blind child, or the child whose home surroundings are thoroughly unsatisfactory so that it requires boarding out of the home. The place of the Blind Institution is for elder children as a secondary school or college, for purposeful training in occupation and technical and workshop practice.

This is direct opposition to the suggestion of the Committee on the Blind, which was "Residential Institutions should be regarded as preferable to day centres for the majority of young children," a point of view quite tenable from administrative convenience, but uneducational and unsocial from the pupils' aspect, and harmful for those intended to mix in the world later.

From the time of the Act of 1893 no great progress had been made beyond the introduction of sight-saving schools for the partially blind, and the Education Act of 1921 has simply incorporated the earlier Act.

In the spring of 1914, Mr. Wardle, the Labour Member for Stockport, carried a resolution in the House of Commons calling attention to the want of social provision for blind persons and their miserable conditions.

A Departmental Committee reported in 1917, and the Blind Persons Act, 1920, made provision for pensions for the blind at earlier ages, and gave local Education Authorities power to promote their welfare under a scheme made to satisfy the Minister of Health. Under this scheme, the school doctor may be called upon to examine blind persons and determine as to their fitness, physically or mentally, for training for certain occupations.

It is always well to consider thoroughly the occupation intended. Sometimes it is quite unsuitable.

Each part of the country has a committee for the welfare of the

blind formed under the Act. A blind infant, when known, now comes under the care of the child welfare section. From the age of 2 years it may be received in a nursery school. There is no compulsion as to education until the age of 5. From 5 to 16 years it comes under the working of the Education Acts, 1921, and except in rare cases of residential pupils in institutions, should attend till 11 or 12, when decision is made as to transfer to a higher type of school, with workshop and manual training. This should be either a residential or day school. At 16 the Education Authority may award scholarships to the blind for higher or technical training, or else after 16 a blind person comes under the scheme of the welfare of the Blind Committee, and after medical examination is passed for training in some industry or occupation.

Grants can be made as gifts, to eke out the scanty earnings of the majority. Except in a few cases the earnings of the blind are fractional, so that no general blind occupation scheme can be devised to pay its way.

The best method would be to give each blind person a minimum living pension, and let him augment it by any earnings he could, wiping out all charities and all voluntary agencies. As Mr. Wardle stated in first raising the matter in Parliament, " A large amount of the funds subscribed to voluntary agencies is utilized to support many sighted administrators." Further, any future State scheme should include provision for excluding marriage between the congenitally blind.

CHAPTER XXVI

READING

Reading nowadays is a widespread dissipation, much of it is almost waste of time. There is excess of reading and writing in school.

Reading should be learned as a tool for educational use. Oral reading, "reading with expression," is a mere pedagogical exercise, one of the spurious results of education, of scanty use in practice.

The teaching of articulation and the phonic values of words should be oral, and apart from reading books, emphasis placed on phonic values destroys much of the value of reading as a tool for acquiring knowledge. In reading it is the value of the whole word, or more still of the phrase, which has to be apperceived, and teaching should therefore be directed to this.

According to such reliable writers as Dearborn and Huey, the careful dwelling upon each word and phrase, which is the daily method of the classical student throughout many years of study, helps not a little in fixing a habit of slow assimilation. Silent reading to grip quickly the meaning of the word is the valuable process. Mere verbalism whether in writing or speech is almost pathological. A passage may be read dramatically and with expression yet the whole substance scarcely apperceived. Beautifully written reports have been published year by year which, on analysis, are almost empty of real information, although a joy to read.

With the enormous amount of reading and writing being done the hygiene of these performances becomes of high importance.

The first task here is to understand how the work affects the eye. If an eye were fixed in one position, as explained on page 467, owing to the rapid decrease of retinal acuity extending from the macula, only about fifteen or twenty letters could be seen in a newspaper held a foot off.

The task of the learner in reading is different from that of the expert reader, the first has to discriminate carefully each part of each word, the other apperceives a word from the merest glimpse of its form.

Eye Movements in Reading.—Facing a person looking out of the window of an express an observer can watch his eyes as they suc-

cessively fix outside objects. The eyes are in constant movement, continually jerking through perhaps 10° or 20° horizontally.

Here the relative angular movement of the objects and the axes of the eyes is considerable and easily seen.

In reading, the axes of the eyes still move, but the book is at rest, and movement is smaller and less noticeable.

One means of subjective observation is sometimes available. The author has a small corpuscle in the vitreous of one eye, usually unnoticed. It can be seen if a very brightly lighted page is looked at, and in reading it moves along the lines like a small, faint comma,

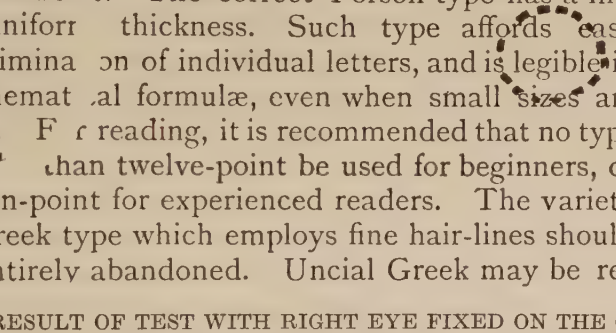

17. *Greek.*—Greek type is troublesome to be··-ners by reason of its unfamiliarity and of the difficult, of synthetising accents and letters into word-who s. The correct Porson type has a line of uniforr thickness. Such type affords easy discrimina on of individual letters, and is legible in mathemat al formulæ, even when small sizes are used. F r reading, it is recommended that no type s. " than twelve-point be used for beginners, or eleven-point for experienced readers. The variety of Greek type which employs fine hair-lines should be entirely abandoned. Uncial Greek may be re-

FIG. 107.—RESULT OF TEST WITH RIGHT EYE FIXED ON THE CENTRE OF DOTTED CIRCLE.

The area of clear macular vision lies within that circle. At the other end of the piece of print is the blind spot enclosed by a white ellipse of blank paper. The print should be held a distance of 10 inches from the eye.

moving just above the line, marking the movements and pauses of the eye.

Much ingenuity has been spent in establishing the physics of the eye movements in reading. Javal, who first worked thoroughly at the problem about 1877, noticed that the eye jerked in small springing movements along the line read and then swept back in one movement to begin the next line. The further off the book, the smaller the springs made. The upper half of a line of print is more easily decipherable, as one may easily see by cutting a line horizontally. There are twice as many ascending long letters as descending long ones, and in a page there occur over four times as many ascending as descending letters.

Javal thought the eyes were centred on the upper halves in reading. He studied the motion either directly or by observation in a mirror. Landolt confirmed his work about 1892, using a little microphone on each lid. He found small movements of the eye

very fatiguing, and suggested this as an additional reason for children holding their work close in learning to read.

Ahrens, at Rostock, studying writing movements, used a small ivory cup applied to the eyeball. Huey (*Psychology of Reading*, Macmillan, 1913), in 1898, applied a plaster of Paris cup to the eye with a hole through the centre.

This probably somewhat restrained the movements of the eye, as the cup's movement was recorded on a kymograph. A high-tension spark every $\frac{1}{150}$ second marked the time intervals.

Erdmann and Dodge (*Psychologische Untersuchungen über das Lesen*, Halle, 1898) at first used the mirror method, then later

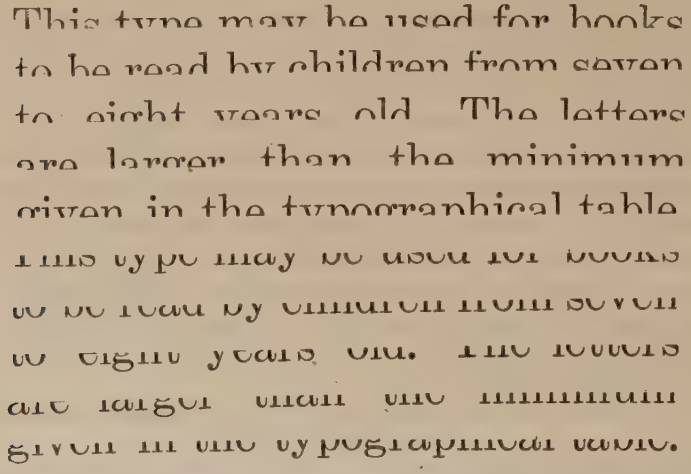

This type may be used for books
to be read by children from seven
to eight years old. The letters
are larger than the minimum
given in the typographical table

FIG. 108.—THE UPPER HALVES OF THE TYPE ARE SEEN TO BE MORE LEGIBLE THAN THE LOWER.

photographed the movement of a vertical line of light reflected from the eye. Even then the head has to be fixed.

Judd, at Yale in 1905, applied the kinetoscope, and, later, Schmidt, at the University of Chicago in 1913, worked out the movements of the globe by photographic records for both vertical and horizontal movement (*Experimental Study of the Psychology of Reading*, *Educational Monographs*, University of Chicago, April 1917).

The eye movements of an average reader are very variable, and the fixation point of the eye is not co-extensive with the line read. The eye is never at rest; there are fine movements even during fixation, so that one should speak of a fixation area rather than point. The range of these fixation movements increases with fatigue, and are shortened by practice.

During the springing movements of the eye, which last about 23 σ, the duration of stimuli appear to be below the threshold necessary for distinct visual impression. The symbol σ here indicates

one-thousandth part of a second. The fixation periods last about twelve to twenty times as long, 200 σ to 400 σ.

The eye in reading a line of 90 mm. will pause from six to eight or more times, then sweeps back to begin the next line, this last movement taking about 41 σ. It is these little springing movements, in following the movement of a motor-car at some distance but parallel to one's own direction, which make the wheels at intervals appear momentarily at rest.

On examination of the photographic records little supplementary movements are occasionally found. The eye is apparently seeking a suitable fixation point. The proportion shewing these movements increases with the length of the line. Dearborn found 58 per cent. with supplementary movements when the line was 107 mm. long, and only 16 per cent. when it was 56·5 mm.

The American Committee on School Books in 1911 state that fatigue is markedly increased by the difficulty of the backward movement and of locating the next line if the line is too long. As a rule the ordinary line of 80 or 90 mm. has three to five fixation points, although there may be double this.

The child or unpractised reader has more. Difficult matter or foreign texts similarly increase the number, but the size of type and reading distance has little influence.

Dodge summarized the forward movements measure from 2° to 7°, the length of line being about 16°. This corresponds at the ordinary reading distance to a 90 mm. line.

The fixation points may be anywhere, in a word or between words. The path of the fixation points only includes from 78 to 82 per cent. of the length of the line. In the practised reader the last point is to the left of the end of the line. Comprehension and association in the memory is said to occur during the pauses of 0·2 second. If these pauses are too short the apperception is defective and fatigue occurs rapidly.

It has also been noted that it is the form of the word rather than the letters which are fundamental. Huey pointed out that there are determining letters. *C*, *ntr*, *m*, are determining for *centrum*, but *ent*, *um*, are indifferent. The first letter of a word is almost always determining. The breadth of the letters is less significant than the height, and the height of long letters helps to build up the word form.

The long letters up or down must preserve the correct relative proportion to the short.

Span of Distinct Vision.—The span of distinct vision as tested with 10 point Roman old style letters, that is, letters 3·5 mm. high at 35 cm. distance, was found by Dockery (*Journ. Ed. Psych.*, May 1910. 123) to be 20 to 22 mm. on either side of the fixation point. The distance between fixations being ordinarily 10 to 20 mm. all

letters come into distinct vision. One can test that for the ordinary newspaper print letters of 1·3 mm. to 1·4 mm. height the span of legibility is not more than 7 or 8 mm. as represented in figures, but this is when using only one eye.

The psychology of reading cannot be gone into here. The history of the alphabet shews that at first pictorial signs connoted definite objects, then ultimately merely sounds, whilst the original picture signs altered to symbols of sounds. Their original meaning was lost, and only the sound indicated remained. Now the letters are built into words, and do not always indicate the same sound.

In English the unit has become the word, and the word form. The logogram, too, as it may be called, does not necessarily evoke the same sound ; it represents an idea. Children made to read as fast as they can, make mistakes and use synonyms, which have no resemblance to the words seen. For instance, Monarch was read as King, stock as stick ; in several instances " cut out its tongue " was read " cut out its tonsils," and so on.

The difficulty of controlling the eye in small movements is shewn by the fixation area increasing in fatigue. There is rapid onset of fatigue when accurate fixation is attempted to eliminate glaring conditions or in poor light. The small movements when reading at a distance were also noted by Landolt as particularly fatiguing.

These observations are in accord with the universal experience that reading small print in a poor light is fatiguing.

The determination of the optimum size of the letters of print is educationally valuable, but again the beginner has to be distinguished from the expert reader. In the case of the learner on looking at a large letter the eye may be fixed on different parts, and muscular sensations remembered ; or the large size may throw a larger image on the retina, and cause a more voluminous nervous impression to go through to the visual centres. Anyhow, very young children with normal acuity will stick at the smaller test types, which they can see perfectly, and will only read them under pressure.

For learners and young children, therefore, letters of print should be larger than for ordinary use, but not so large that they exceed the span of distinct vision. The largest specimen given by the British Association Commission was 30-point Caslon, the letters 4·2 mm. high. This is at 30 centimetres, about a quarter of the size as limited by the span of vision.

On the ophthalmic aspects of print the great authority is Cohn. The title of his last work on the subject, *Wie sollen Bücher und Zeitungen gedruckt werden*, is printed in a tall, narrow, comparatively illegible type. A good practical Report on the Standardization of School Books was presented to the American School Hygiene

Association and printed in the *American Physical Education Review*, 1911. 254.

The subject has been worked over, perhaps too minutely for practical use, in the Report on the Influence of School Books upon Eyesight by a Committee of the British Association in 1913.

A paper of interest to educational workers illustrating the enormous amount of thought which has gone to the making of usable type is *A Note on the Legibility of Printed Matter*, by L. A. Legros (The Stationery Office, 1922).

For the avoidance of glare it is desirable to have paper without gloss, hard enough to take a clean impression, and not to be easily dirtied. Hard enough, too, not to allow the pressure of the type to spoil the evenness of the reverse surface. It must be thick, and opaque enough to prevent any shining through of print from the reverse side. Burnished " art " and super-calendered papers will thus be excluded. Coloured papers are to be avoided as they mean loss of contrast with the ink. If any colour is used, it should be the faintest grey, green, blue, or cream tint ; all reds are objectionable. Wood pulp in paper is said to promote shining through, and to make the paper wear badly. A drop of aniline sulphate solution gives an intermediate brown stain to wood tissues.

The ink required is as dead black as is procurable, neither the pressure of the type or drying of the ink allowing polish on the black surface. The optimum surface brightness of the paper is about a hundred times that of the ink. With cheap inks this contrast is often much less.

Cohn publishes appendices printed in four different tints of ink in the above-mentioned work, shewing clearly the great importance of good ink. Coloured inks in letterpress should be avoided. On examining school books some were found with coloured inks for different letters, the yellow letters were invisible a foot off with + 1·0 D. or + 2·0 D. glasses, amounts corresponding to the majority of hypermetropic infants, shewing that to a large percentage these letters were almost illegible.

Red inks with black are irritating, and may not appear in the same plane. On the other hand, coloured lines in maps and diagrams may be valuable.

The Russian Government in 1905 published a short official note on school books and materials, concisely summing up the following conclusions—

A. 1. The text of lesson-books and materials must be simple and legible, without ornamentation or flourishes.
2. Italics, being difficult to decipher, are not permitted, and should be substituted by heavier or spaced letters.
3. The height of the small letters should not be less than 1·75 mm.
4. The ground strokes of letters must not be thinner than 0·25 mm., and the distance between the strokes not less than 0·5 mm.

5. The average distance between the letters should not be less than 0·5 mm.
6. The average distance between single words not less than 2 mm.
7. The distance between lines not less than 3 mm.
8. The number of letters in a square centimetre of print must not exceed 15.
9. The length of line must not be more than 100 mm.

Note.—For primers, letters must be 3 to 4 mm. high; for beginners, not more than 3 mm. or less than 1·75. For the three highest classes, books may be used having letters not less than 1·5 mm. For dictionaries and arithmetical tables, letters may be smaller than 1·5 mm. but must exceed 1 mm.

For remarks at the foot of pages, and on geographical writings, letters must not be less than 1 mm.

B. 1. Concerning paper and print.

The paper must be so thick that the print cannot shine through on the other side (not thinner than 0·075 mm.), of white or yellow tint, even, smooth, without shine, and with not more than 10 per cent. wood pulp.

2. The printing ink must be a saturated black with a clear and even impression.

The American School Hygiene Association gave a simple, easily remembered statement as to minimum sizes of desirable type, based on the letter *n* in fractions of millimetres.

TABLE 80.

	Height of Letter.	Width of Vertical Stroke.	Space within Letters.	Space between		Leading.
				Letters.	Words.	
	mm.	mm.	mm.	mm.	mm.	mm.
For adults ..	1·5	0·25	0·5	0·5 to 0·75	2·0	2·5
For children—						
Older ..	1·6	—	—	—	—	3·0
Medium ..	2·0	—	—	—	—	4·0
Younger ..	2·6	0·4 to 0·5	0·8 to 0·9	1·0	3·0	4·5

In practice, type is measured in England and America by printer's points of which 72 go to an inch. This determines the body of the type, which is much larger than the small letter, as provision has to be made on it for the up or down strokes of the long letters.

The face of the letters on the type, on which depends the size of the printed letter, is not necessarily fixed by determining on type of so many points. The 24-point type has a vertical edge of the body equal to 24/72ds. of an inch, that is $24 \times 0 \cdot 353 = 8 \cdot 4$ mm., whilst the usual small letter set on it is only 2·8 mm.

The 14-point type has a body of 4·95 mm. and letter size about 1·65 mm., and the 11-point body is 3·88 mm. with a letter 1·3 mm.

In any specification to fix the sizes of print in books the simplest definition can be got by determining a limiting height for the small letter, say of the *n* not less than its height, and a minimum interspace clear between the lines of double this height. If this is done, the rest can be left to the printers to arrange.

Minima, which the writer suggested after experimental enquiry, were—

Infants below 7 years : 24-point type and small letters 2·8 mm. approx. 8 points.
Children of 7 to 9 years : 14-point type and small letters 1·75 mm., approx. 5 points.
Children over 9 years : 11-point type and small letters 1·50 mm., approx. 4 points.

As the types are sometimes leaded, 24-point up to 28-point, and so on, it is well simply to define the smallest space occupied by each

Fig. 109.—TYPE BODY AND TYPE FACE.

line as three times the height of the face of the small letter. In any case, the interspace between lines should not be less than a thirty-fifth of the length of the line, to aid the eye in picking up the next line in its sweep backwards.

Since 1902 the Berlin Regulations for school books give minimum 1·5 mm. letters and 2·5 mm. between lines.

For practical purposes Cohn's square centimetre test, as recommended in the Russian order, is the readiest ; not more than two lines of print should be visible through a square centimetre opening.

This test was improved by Schubert, who stated that the density of the printing should allow not more than 15 letters to be visible through the opening.

R. T. Williamson, in 1906, found that out of 250 school books in

Manchester 44 per cent., and of the mathematical books 67 per cent., failed to pass Cohn's square centimetre test.

The British Association Committee tabulated their recommendations as to type in a Standard Typographical Table—

TABLE 81.

Age of Reader.	Minimum Height Face Short Letters.	Minimum Length of Alphabet of Small Letters.	Minimum Interlinear Space.	Maximum Number of Lines per vertical 100 mm.	Maximum Length of Line.
	mm.	mm.	mm.		mm.
Under 7 years ..	3·5	96	6·5	10	—
7–8 years ..	2·5	72	4·0	15	100
8–9 years ..	2·0	55	2·9	20	93
9–12 years ..	1·8	50	2·4	22	93
Over 12 years ..	1·58	47	2·2	24	93

These are somewhat larger than sizes in the writer's suggestions.

There are about fifty varieties of founts in common use, and it is important that the face shall be as simple as possible. The unornamented simple outline letters, known as *sans serif*, or gothic or grotesque, and in Germany as Steindruck, would seem the best, but owing to irradiation they are not as legible as letters with thicker ends.

The old manuscript work shewed thickenings due to the broad quill nibs used in writing, and these were imitated in the serif endings. These thickenings should be quite slight, and nearly terminal. Anything like ornamentation or flourishes about the upper parts of letters detracts from legibility. The most legible is the modernized old style face, or old style antique. The Caslon old face has been famous for a century, and is the main inspiration of our type foundries.

The legibility of figures is also worth consideration. The old-style figure, where the figures 3, 4, 5, 7, 9, come below the line, and 6 and 8 go above, make them difficult to read in cross rows.

Modern faces for figures are all the same size, and should be preferred for tabulations, logarithm books, and when lines of figures are to be followed horizontally. Where letters are printed as symbols in mathematical work, the symbols themselves, being logograms and expressing more than letters of the text, should be larger and markedly different. In other educational work one type and spacing should be used as uniformly as possible, in order that word forms as logograms may be quickly and easily remembered.

The forms of the letters as shewn in Legros work have all been worked out carefully. In some cases with the letters used for beginners a thick down stroke and thin cross strokes give what Bishop Harman calls a palisade effect.

Compressed faces may thus be more difficult to astigmatic persons; expanded faces are also to be avoided as destroying the word form to some extent.

Much has had to be done to make optical and printing requirements agree. In the case of such letters as B, for instance, the white circular spaces or "counters" have to be maintained so that the actual shape of small letters of the same fount, and having to the eye somewhat the same appearance, is very different if they are all magnified up to letters of three or four centimetres height.

Printing again from actual types is sharper than from stereotype plates. When magnified up equally the one impression has a sharp black line for edge, whereas the other is crenate and indistinct.

Infants learn their letters by combining many memories, especially muscular sensations, kinæsthetic memories, either of arms and hands, or of eye movements. When experiments were made a quarter of a century ago, it was found that infants learned visually quite quickly, but forgot the letters learned in a few minutes. It was also found that children saw things very differently from adults. Set to copy letters from the blackboard, several in a class were found to have slight diplopia, or even polyopia, to judge from the drawings made in the form of apparently overlapping letters. By using colours, by drawing the letters large, by kinæsthetic feeling, describing the letter with the finger in the air, making letters with bits of telegraph wire bent to shape by the children, by stick laying, or writing with the finger on a sand-tray, or by feeling cardboard letters, the symbols came to be memorized, then the written forms followed in chalk on the blackboard.

The importance of letters before the age of 7 is exaggerated by teachers. It would be better if they were not permitted to be read or written in school before this age, especially as for probably 10 per cent. of children they never have much practical use in later life, being largely forgotten. Teachers sometimes say they would not know what to do with the children if not thus taught at 6 or 7. There is abundance to be done that is neglected.

W. S. Cornell observed that without definite standards the examiner tends to grade the child higher than its capacity, as the child reads easy words which are the majority. He uses sample texts with 50 test words in each and neglects the context of easy words. If the child reads 35 out of 50 test words correctly he is credited with 70 per cent. marks (*Training School Bulletin*, 1915). His experience that many children coming to the Philadelphia House of Detention over 14 years of age, possessing employment certificates based on a recorded ability to read and write intelligently, nevertheless prove to be illiterate, agrees with the author's observation of young factory hands, many of whom between the

ages of 20 to 25 were unable to name the ophthalmic test letters although they had spent seven or eight years at school. No doubt many have learned a few simple words but have never really had intelligent power of reading, and lack of subsequent exercise in reading leads to complete forgetting of the process. In one case where a boy worked long division sums correctly in the writer's presence, and whose papers he had preserved, five years later the lad had forgotten all beyond the addition of integers although he was now an intelligent worker getting good wages. Therefore he concluded that reading is a much overrated element in elementary education and of scanty practical use for at least 10 per cent. of school children.

After twenty years' observations at Vineland it was concluded that a child of 12 with mental level of VIII years was unsuitable to attempt the learning of reading, and that a child of 11 who could not read a Standard I reading book, the equivalent of VII mental age, will not learn or be able to use reading.

Irradiation plays a part in the reading of print. A bright point appears bigger, a dark point smaller than reality. White chalk lines on the blackboard will therefore, if the white is good, appear better than the corresponding size of black letters on white. The relative invisibility of thin black lines on a very white ground is due to irradiation. In the myopic schools, square chalks are likely to give a more visible stroke than the usual rounded forms. For writing on the blackboard to be legible at the maximum distance of about 30 ft. in a class-room, the letters must be at least 2 in. high, as some of the children will at some part, if not all, the day have visual acuity not more than half of normal.

Many years ago Dr. J. R. Kaye (*Journ. Roy. San. Inst.*, 1905. 106) suggested that good paper and black ink was all that was wanted till we can get white letters on black, so that the letters only stimulate the retina, instead of the large negative portion of the page doing so. With such white print on black there appears to be less glare, and possibly the pupils are more dilated. It is said that the private newspaper of the Paris undertakers (*croque-morts*) is printed in this way.

White print on black appears smaller and clearer but probably would soon dirty, and at present has practical difficulties in the way of production.

The different legibility of 26 different faces of printing from 10-point types was investigated by Barbara Rothlein at Clark University (*Amer. J. of Psych.*, 1912). The type known as news Gothic, which are simple letters similar to those on page 554, was found most legible. Legibility increased with boldness until the thick black lines began to reduce the white counters, and with condensed or compressed types, in spite of boldness

the letters became less legible. Interlinear spacing was also important.

So far, it has been assumed that simplified Latin letters are the best for reading, but on the Continent the German type or Gothic print, which is a degenerate ecclesiastical production from the Latin, is largely used still, and discussion goes on as to whether Latin or "Fraktur" (German) is the best.

The Latin letters are acknowledged as most legible, but from the point of view of logograms several German writers claim that the Gothic print is most legible. Probably, however, this is because they are most accustomed to words in that print, and one reliable worker—an Alsatian trained to French—got reverse results in the same laboratory as his German colleagues.

Italics, invented by Aldus in 1490, may here be left out of consideration.

The great improvement in myopia in higher educational institutions in Sweden during the past generation has been attributed largely to the abandonment of Gothic print formerly used for the more simple Latin type. There was also much discussion in Germany before the War as to whether the first letters taught should be Latin or German characters.

The simpler the letters the better for the child, and it learns quicker with one alphabet; the Latin capitals are the easiest (Soennecken, *Fraktur oder Antiqua im ersten Unterricht*, 1913). The German child has eight alphabets to learn.

Lehmensick proposed to use the Latin letters in their simplest form for teaching reading (Rein's *Encyclop. Handb. d. Padagogik*), and J. Spieser, an Alsatian parson, reduced this to a simple form for either print or writing. His "Fibelschrift" (*Zeit. f. S.*, 1898. 434), although even he proposed to retain the long ſ for one form of *s*. The form of the letter with thick strokes all through is best for the small child; later the characteristic thin and thick strokes increases legibility for the practised reader.

This simplified alphabet is the easiest to learn and remember, and it was the form into which the children in the writer's experiments half a dozen years earlier bent their pieces of telegraph wire. Kaye suggested (1905) that a special school-book style of simplified type was desirable, with which the writer thoroughly agrees.

When writing is considered, it has been further simplified in the last ten years in English schools as the so-called manuscript-writing or script-writing alphabet, inspired by Spieser's Fibelschrift. The news Gothic, which is the type face nearest to this, is also the most legible.

Coloured letters may have varied legibility. A distinguished educationalist once remarked that he was losing the power of seeing

figures in red ink, which he regained on following the advice given about tobacco. So, too, many letters in infants' books may be invisible to children with refractive error. Dr. Gibson (*Cheshire Report*, 1912) found that in certain primers the black letters were visible at 128 in., blue and red at 100, yellow at 48. With + 1 or + 2 interposed yellow at near point were invisible, blue invisible with + 2 or + 3, and the black letters only when + 7 was interposed. These coloured letters must therefore be taken as inadvisable.

Format.—Apart from the type faces and spacing there are several considerations in regard to school books. It is generally agreed that no line should exceed 100 cm. (4 in.), but the nearer 70 cm. probably the better. There is difficulty in keeping to the lines if they are too long or too close together, either a line may be missed or re-read.

The ancient Hittites read their writing in alternating directions, and some of the most ancient Greek inscriptions are boustrophedon, that is, like an ox ploughing down one line left to right, then up the next right to left.

Young children sometimes tend to write this way in their earliest spontaneous efforts. Mlle Varia Kipiani, of the Brussels Laboratory, proposed (1913) that reading should be done this way to spread the effects of fatigue more generally over the alternate sets of muscles. It is extremely doubtful whether there would have been benefit.

In the arrangement of the page a good margin is requisite to isolate the reading matter, and help to guide the eye. This should not swing off the page in sweeping back to begin a fresh line. Overcrowding the page may be a serious and fatiguing mistake. A useful rule for school books makes the sum of the width of the side margins one-half the width of the line of type. Of the marginal space the greater part of the width available should be given to the left-hand margin, and the inner margin wide enough to prevent the curvature of the paper obscuring the end of the printed line. Further, the head margin should be equal to the narrow-side margin and the width of the margin at the foot a sixth more than that at the head, according to the canons of beautiful printing.

For the hard wear required, school books are best stitched with linen thread to tapes. They then open flat, which stabbing or side stitching prevents.

Wire sewing or staples are objectionable, and officially forbidden in Sweden.

Illustrations for school books require simplicity of treatment and absence of confusing detail. The best effects are obtained from broad contrasts of light and shadow. Line illustrations are pre-

ferable to half-tone work both from visual and educational considerations. Black and white work is the only kind necessary for ordinary school purposes. Of course, in the case of maps and complicated diagrams different colours often add enormously to the clearness and legibility where otherwise detail would be confused and involved.

The pictures should be bold outline, portraying action as far as possible and without overlapping figures. Only one picture to a page saves confusion. The printing of numerous small pictures in the margins is inadvisable.

In reading, young children tend, as with all fine work, to hold the book too close. The reading distance should be as far off as convenient, to save both convergence and accommodation of the eyes, at the same time remember that the smaller eye movements are fatiguing in running along the lines. An optimum distance is 10 to 14 in. The position with the head bent over the book is bad, as causing congestion, and through this tending to produce myopia. The position with bent back and stooping shoulders, giving small play to the chest, contributes to cause bad health in the book-worm of later life.

Reference Books.—Attention has been called to the use of fine types in Bibles. The inclusion of the mass of printed material in the Bible in one handy volume means small, compressed printing and very thin paper, any extensive use of which would result in effects of serious import to children's eyes.

There is no reason why with a large demand separate books of the Bible should not be printed for school use. The Gospels and the Acts of the Apostles are the New Testament books most used. The books of Joshua, Kings, Chronicles, Psalms, and Isaiah would cover the greater part of biblical usage in schools, and for the slight degree to which other parts are used the small type of the present editions might be suffered. Bibles might be suggested in small type, with much-used parts in larger types of clear face.

For higher-grade schools and institutions, where dictionaries, reference books, mathematical tables, or other important books are used intermittently, the amount of usage not being considerable, and the convenience of portability and small type being very great, exceptions might be allowed. In libraries or literary work-rooms of such institutions the place lighting should not fall below a minimum of 5-foot-candle-power.

Written Words.—The learner forms a word memory which is composed of letters in a certain spatial relation, it will facilitate legibility in reading script if the same relative proportions, and so to some degree the same relative word forms are preserved in writing. Teachers, as a rule, have not appreciated the great educational value of this correct spacing.

The small letters of written words should, therefore, approximate to the circle or square equal to their height, and the approach or distance between two letters as in print approximate to one-fifth, not more, of the width of the average square containing a small letter. This would eliminate the grotesque copies seen occasionally, where neat but nearly illegible script seems to consist of very narrowed letters separated by five or six times their width crossed by oblique joining lines.

CHAPTER XXVII

WRITING AND DRAWING

Writing and Drawing are really developments of the one mode of graphic expression, which in its most primitive form is spontaneous drawing. Used for signs this becomes conventional and artificial as writing, of which there are two forms : (i) Pictographs, each when conventionalized representing an idea, a word. (2) The alphabetic, in which each sign means only a sound, a letter, combinations being used to build words.

Spontaneous drawing preceded any reading. Drawing is, therefore, the earliest graphic expression, and should be the first encouraged in the child. The formal teaching of writing should be delayed as long as possible.

The four main reasons for excluding teaching of writing as a formal exercise from the education of children below 7 years of age are—

i. Each hour of desk-work before seven is deprivation of more general muscular activities, so necessary for development and nutrition.

ii. The young child's undeveloped eye makes near work an excessive strain, and leads to bad educational habits.

iii. The nervous effort required in both eye- and finger-work with fine objects is so great that children do not make the effort without strong inducements ; they are thereby readily fatigued, and it is quite probable that such efforts have bad results on later nervous development.

iv. The easy fatigue of young children leads to attitudes, which in many cases result in spinal curvatures and contracted or undeveloped chests.

Even the earliest drawings of children are conventional, as they were also in history. The old Egyptians drew their figures in profile but with one eye in full front view on the face. So with children, a hand has all its fingers spread out. The front of a house is shewn with the window in a corner, like a postage stamp on an envelope, and often the gable end in full front view. The natural method of drawing first forms a mental image, then transfers it to the board or paper. Draw a tilted crescent moon on the black-

board. Shew it to the baby class for a couple of minutes; then remove it, and ask them to draw it. The results shew the mental process by which drawing is accomplished. So, too, test the next class, with copying of some English letters, with one or two Greek or Russian letters unlike any English. Some of the children will probably mirror some of the English letters, but this will not happen with any of the others of which they have not previously formed a mental image. Object drawing seems the real way of teaching. The old-fashioned free-hand copying of outlines drawn by the quarter-inch, with much use of india-rubber till a good result was obtained, destroyed both spontaneity and artistic expression. It forced a child to premature use of the undeveloped fine muscles of the fingers, whilst it strained the eye. As an educational method it seems to have been wholly bad.

It does not matter how bad early efforts at drawing may be, if rapid rather than exact work is asked for, the subconscious adjustments will be made, so that constant improvement follows. The earliest drawings should not be small or restrained by paper or narrow boards. They should be scrawled on the wall or wall-boards at arm's length, although too much of this is fatiguing. If any formal education for the six-year-old is attempted, it should be long strokes, vertical or horizontal, then sloped right or left. After this come long ellipses, then broadening out till the circle is reached; first all of one size, then big and little. Attempts at good exact work slowly done at early ages merely make demands on fine adjustments with much effort for the attainment of what are educationally spurious results. So long as a child expresses an idea intelligibly at this age it does not matter much how it is done. The quicker it is done, the more likely is it that true education is being accomplished by almost subconscious efforts and adjustments. Years ago (*Ann. Rep. Med. Off. Ed.*, 1910. 45) a summary was set out: "Free-arm drawing at arm's length, the child standing erect, printing and writing, extensively used in the infants' school, could be made to replace entirely the teaching of writing by laborious methods. The muscular sense of space and form being accurately developed, there is little need for writing on paper till the children have learned to write or print words clearly and easily, and the longer any small writing is delayed during the early years, the more successful is the ultimate result likely to be as regards clearness and intelligibility in the good form and shape of letters."

In this rapid free-arm work at the blackboard the use of both hands in an attempt at bimanual work is useful as training to rely on the muscular sense rather than the eye, as obviously one cannot see both hands at once. These simultaneous arm movements give a better realization of proportion and develop a kinæsthetic sense of space which is valuable. It is probably the only instance in which

support can be given to the training of the left hand as a special educational proceeding.

Attempts made in working at the blackboard with a thin line and small scale movements of the fingers are not free-arm work such as the small child requires. This cannot be done in desks with millboards. Such desk-work is camouflage for the real educational work that should be provided. This free-arm work is restricted in English class-rooms whilst they remain the smallest in the world, on the 9 sq. ft. per head basis for infants. A large part of the all-important hand and eye training in the pre-standard child is thereby excluded.

Drawings.—Pictorial expression or pictographs should be developed as a definite stage of the infant school curriculum. The children should be encouraged to illustrate things seen and heard. The intelligence of different infants shews up in this, more even than in Binet's tests by description of a picture. From pictographs they will pass easily to the conventional word images of writing.

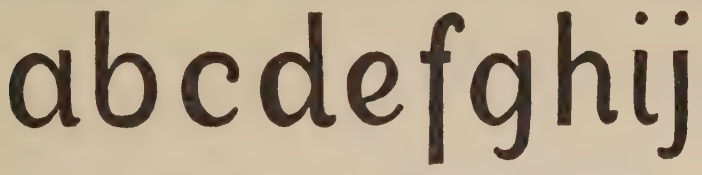


FIG. 110.—THE SIMPLEST ALPHABETIC FORMS.

Letters have to be learned by sheer grind, although some children seem to pick them up without teaching. The young child has little on which to fasten. It learns the letter and forgets it in half an hour. It is really yet too immature for these memories to be retained. Every advantage must be taken of the play apparatus to develop the kinæsthetic sense of letter forms (p. 553). The muscular memory and the sound attached to the letter is thus permanently acquired, and often the children themselves will begin to letter their drawings. Indeed, at first, many of the letters spontaneously written will be laterally inverted, mirrorwise. This is a regular stage in normal development before the full sense of dextrality is acquired.

In making their first letters, English children seem to incline to the Latin capital forms, whether on account of seeing them so prominently on signboards, or of seeing them larger on pages of print, or whether their simpler form is easier to remember. A letter represents a shape and a sound ; it must be felt and heard, as well as seen. Spelling merely by ear is bad, printing letters are needed to round off the word image.

The beginner's alphabet should be reduced to one, the simplest form possible, straight strokes and hooks. Both printed and

written letters should be in the same simple alphabet. The script writing printwise by single letters is the only writing which should be taught or used in the primary school. It is easier to learn, neater to produce, speedier to write, and more legible than any other forms, and eliminates many problems over which European ophthalmologists and orthopædic surgeons waged strife through the last generation.

The simplest writing stroke, when writing at a desk, is not a vertical line, but one at a tangent to the circle, of which the writing elbow is the centre, in the direction from the pen point to the centre of the breast-bone. This normal writing tends to slope downwards to the left. For children standing at the blackboard vertical script is the easiest and most correct form, but reasonable allowance must be made for any slope that results from writing at a desk.

In education, as in all Nature, the principle of the path of least work must be followed, and there is less adjustment of position required for a sloped stroke in a copybook than for a vertically written one. Even with the long strokes and highly sloped letters of the German writing this is probably true. There is, however, less actual writing in the vertical methods.

In a paper on L'écriture droite by Otth (*Jahr. Schw. Ges. f. Schulges*, 1910. 110), he analysed sloping writing and vertical script, shewing the advantage of the last to be as 4 to 3—

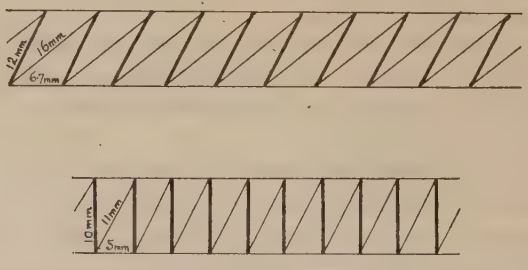


FIG. 111.—SLOPED AND VERTICAL WRITING SHEWING SAVING OF SPACE AND EFFORT BY THE LATTER (Otth).

10 thick of 12 mm.	= 120	10 thick of 10 mm.	= 100
10 thin of 16 mm.	= 160	10 thin of 11 mm.	= 110
	280 mm.		210 mm.
Length of writing, 67 mm.		Length of writing, 50 mm.	

He did not notice that the approximation of the vertical writing to the printed spatial form rendered it also more legible, and that incorrect spacing between letters, especially letters like *i* and *l* and the round letters, is the most frequent error.

Mediæval writing of a formal nature was vertical, printwise. Writing was taught as vertical. A copperplate by Holbein (1516)

shewing the room of a writing master represents vertical writing. Cursive script written in a hurry sloped, and the printed italics were got from a fount of type to imitate this writing. Sir Isaac Newton was the first prominent Englishman to slope his writing. In France writing was vertical till the beginning of the nineteenth century, when the quill was supplanted by the steel pen, and to-day throughout France and Italy a sloped script is known as the English writing.

Practising letters and then written symbols by free-arm work entails no undue strain on the child.

For an infant, writing in a copy-book or on narrow boards is a very different matter. The same strain described in connection with reading falls on the undeveloped eyes, but now is unequally shared. The fine muscles of the fingers are called on for work which they cannot fulfil, and overflow results come in the puckered brow, the protruded tongue, and the spasmodically gripped pen or pencil with the second joint of the index finger bent up to an acute angle. Attempts to keep the body steady, impossible for more than a matter of seconds with the infant, mean all kinds of twisted attitudes. These signs of general nervous overstrain make some form desirable for learning writing free from such demands on immature organs.

If it is attempted to keep the eye-work distance great enough, say down to not nearer than 25 or 30 cm., the average six-year-old could not reach the work at that distance. Greness, a Norwegian observer (*Buff. Cong. Rep.*, v. 124), pointed out that the children of the first three years could not use the 20 cm. high copy-books provided ; they ought not to be more than 16 cm. for these children.

Again, the teaching of handwriting to children by copy entails fine eye adjustments which are a severe strain for any accurate result. There should be no network of lines, thick and thin and dotted. Fortunately they are passing. The last of such schemes was probably a book on the Unit System of many and intricate guide lines—such a system being thoroughly bad for the seven-year-old. It was systems of this kind, with various types of guide lines, some at crossing angles, which caused the demand for abolition of sloped writing. Attempts to rationalize writing had been made. Copy-books for upright writing were published in Venice in 1808, and Mathias Rob in France advocated it in 1862. This mode of writing came up at the Hygiene Congress in Geneva in 1882, and was finally recommended by a Commission of the Town Council of Nuremberg in 1890, whose Report constituted the most scientific examination of all aspects of writing which had ever been made, chiefly owing to the work of Schubert, the ophthalmologist. The Report sets out as desirable for a writing alphabet—

1. It should have the greatest fluency and freedom of form, especially in the interrupted progress of the pen from one letter to another. Therefore it needs—

(*a*) Simplicity of form ;

(*b*) Avoidance of all strokes and turns not absolutely characteristic for the letters.

2. It should make the forms of different alphabets as near each other as possible.

3. Shorten the upper and downward strokes of long letters to increase the size of short ones. (This refers to the German script.)

4. There should be no discontinuity with present forms.

Schubert recognized writing as a factor in myopia production. He said that in later life a person may write as he will, but during school-days, in the period of growth, asymmetry of body and eye leads to twisted spines and myopia.

Earlier writers, Fahrner in Zurich, Gross in Stuttgart, had blamed the oblique, right-sided writing as the cause of most troubles.

The Eye-strain of Writing.—The copy-book can lie (1) in a straight, central position, (2) in a straight, right-side position, (3) in an oblique, central position, (4) in an oblique, right position. Left-sided positions being here omitted.

Schubert knew that with the straight, central position the eye easily followed the right, oblique writing line, but that anatomically the wrist does not permit this. He shewed that with (2) the straight, right position the oblique writing was easy, but that the left eye must describe five times the arc of the right; further, that with an extreme right position the left eye at the beginning of the line had a right deviation of 25°, and at the end about 48°. Even with the paper only 10 cm. to the right the fixation point had to be turned to a degree that the child could not maintain. If this has to be compensated, the head must be rotated 34°, but this cannot last as the head joint only permits a maximum of 45°, so to avoid fatigue the body is turned to the right, and thus the position starts which leads to near approach of the eye to work. There is also unequal accommodation, as the beginning of the line is about 2 cm., the middle 3 cm., and the end 4 cm. nearer the right eye than the left.

With the oblique, right position the writing lines run from left below towards right above. The basal line symmetrical to the axis of both eyes should remain at right angles to this, but through turning of the eyes it follows obliquely the oblique copy line. As the retinæ are not now symmetrical, conflicting circles arise in the periphery, and to avoid this, the head is bent to the left shoulder as long as the basal line is parallel to the writing lines.

Finally, as the oblique, central position combined both objections, Schubert recommended vertical central writing. In this position, he said, only vertical writing is possible, whereas in all the others the usual right slope occurs.

Opposition, however, soon came to the vertical writing. The chief was that it was a waste of time, as the sloping was much speedier. The only answer Schubert had was : *Das Manchestertum gehört nicht in die Gesundheitspflege*—"The cheapest wares have no place in hygiene." His real answer, of course, was that this was a protective educational method only necessary during the plastic growing period. It was soon evident that vertical writing could not be maintained. Frequent pauses were required in the lessons. The writing point is not seen if the pen is held as directed, not a disadvantage if the head were not twisted to the left to see it. After being introduced almost everywhere it was condemned in Holland, in some Swiss towns, and even in Schleswig-Holstein, after years of trial, was officially forbidden from Easter 1898. All kinds of efforts were made in the interests of vision. The writing was to be vertical at first and to go over to slope later. At Quedlinburg, the ancient town in the Hartz, as in spite of all directions the children sat badly, a leaden ring 20 cm. across with the inner edge bevelled to fit the head was set on the top of the child's head, and if it did not sit straight up the ring clattered off (*Zeit.*, 1904. 36). So much that has been written, particularly by ophthalmologists, about writing has been based on work done with German writing, that it has to be greatly discounted in reference to English schools.

In France, Drs. Péchin and Ducroquet (*La Med. Scolaire*, 1909. 136) re-studied the vertical writing and found it straining to the arms, and right sloping writing reverted to, or, in the case of vertical writing, it often went over to a left slope to save fatigue.

Wrong Attitudes in Writing.—The problem of the writing attitude is to find a posture allowing freedom to write, giving support against muscular fatigue, and yet avoiding tendencies to deformity, such as lateral spinal curvatures (scoliosis) from one-sided support, and the anteroposterior curvatures (kyphosis) from the near eye work habit, and myopic changes in the eyes.

To ensure sufficient space for freedom in writing each child should be able to sit in its place with both forearms along the lower edge of the desk and the palm of one hand over the backs of the fingers of the other. The body should be kept square with the desk, the back erect, the feet planted equally and firmly on the floor, and the chest clear of the lower edge of the desk.

Probably the best writing position is with the left forearm and elbow on the desk, the left hand steadying and controlling the writing surface, the right forearm being on the desk and the pen nearly parallel to the arm. The elbows thus point outwards. This is not tiring and avoids any rotation of the trunk.

A position with both elbows off the desk is sometimes illustrated with apparatus devised to prevent near eye work distances. Although at first it keeps the back straight and prevents near eye

working, it is very tiring to both back and wrists, and there is speedy relapse into some other position.

Where the left elbow is on the desk and the right off, there is a tendency to twist the body clockwise. Some of the newer American seat-desks make a considerable point of the right bracket support for the arm and elbow, preventing this rotation, and probably it is a considerable advantage.

The commonest bad attitude is the sprawling position which results from putting the left elbow well on the desk. Some teachers make the children put their hand round above the writing to prevent copying, and also to save space where the desk allowance, as in nearly all English public elementary schools, is too little. The body is twisted to the right and the spine arched forward and to the left. The child on the left hand in a dual desk is pushed over by his neighbour's arm and himself hangs over the edge of the desk with resulting spinal rotation.

R. Berlin, of Stuttgart, who studied the attitudes in writing from the ophthalmic standpoint, reduced them to three : (i) the erect, square position with least stoop ; (ii) bending to the left, the most uncommon position, with the pelvis either straight or left oblique ; (iii) the commonest is bending to the right with the face close to the desk and book, the pelvis to the right, and the greatest amount of stooping and head rotation.

The Muscular Strains of Writing.—English and American observers have paid most regard to writing as a muscular effort. Drever (*Proc. Roy. Soc. Edin.*, 1914. 230), by isolating separate movements, found the finer movements due to the fingers, and the faster the writing the more it becomes hand, then arm work. In children, hand movement is commonest. The pressure, too, has to be carefully adjusted. The cheirograph shews that the adult probably writes from a whole word image, whereas the child has separate strokes and separate letters. Meumann regarded the child's writing as a series of separate or distinct strokes.

Bryan (*Am. J. of Psych.*, v. 1892), testing tapping rates, found that the rapidity increased with age, and that finger movement acquires a large part of its ability, about 20 per cent., after 9 or 10 years of age. When speed is decreased the accuracy due to vision increases, but with increasing speed it is muscle control that comes in. Woodworth (*Psych. Rev. Supp.*, 1899. 71) concluded that the eyes of a writer do not follow letters but only general alignment, and in forming letters we depend mostly on muscular and tactile sensibility.

Just before the War, in the Brussels Laboratory, Mme Ioteyko and Mlle Kipiani contended that it is wrong to train children to use their eyes on what they are writing. It is a source of fatigue which may also contribute to myopia. When a test was made with the

blind and with blindfolded persons their result shewed that the main use of vision was for alignment.

McAllister (Yale Psyc. Lab., 1900) found most of the movements of writing might be described as in the quadrants of the clock-face. The rapidity of the movement in the first quadrant XII–III being taken as 1, that of the quadrant IX–XII is 30 per cent. greater. In the third quadrant, VI–IX, it is 10 per cent. less, and in the last,

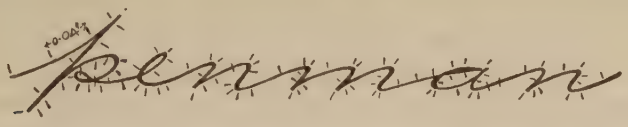


FIG. 112.—WRITING BY AN EXPERT STUDIED BY THE KINEMATOGRAPH.
The space between each pair of dashes is one-twenty-fifth of a second (F. N. Freeman).

III–VI, is 25 per cent. greater. He concluded that the natural slope is the most rapid, but that as it decreased below 70° with the horizontal it becomes more and more illegible. He thought an orienting base line desirable to guide the eye. Free movements are better made towards the body, up strokes take more time than down. It is desirable that the child connect letters to give it time to estimate the space between, and keep the letters at the same level. Speed is of little importance at first so long as the muscles

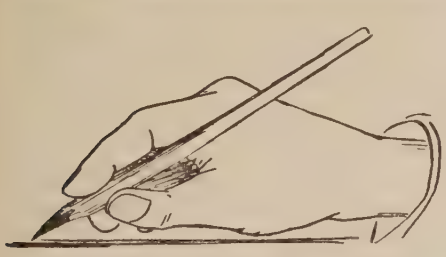


FIG. 112A.—PRACTISED WRITER.

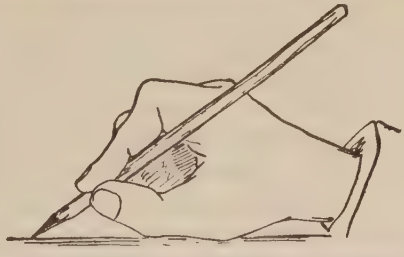


FIG. 112B.—UNSKILLED AND YOUNG CHILD'S ATTITUDE IN WRITING.

are educated to fairly correct letter forms. There is great strain of hand and arm to keep constant pressure for all strokes.

F. N. Freeman, in his study (1915–18) of "The Handwriting Movement" by the kinematograph in the Chicago University, has given a comprehensive idea of the muscular mechanisms in action (*Supp. Educ. Monog. II.*, No. 3). Everything was shewn except the varying pressures on the pen. It demonstrates that all loops and turns take up much time. Separate letters appear to depend upon the fingers; words on the wrist movement. In the analysis of a practised writer it appeared, contrary to McAllister's observation, that upward strokes were usually quicker than downward. Support of the hand on the third and fourth fingers seems preferable to

the side of the hand. The forearm at right angles to the line of writing is best. There appears to be no relation between good writing and the angle of the pen in the down-strokes. In training children the spasmodic grasp of the penholder is gradually eliminated, and the finger should be lower on the penholder than the thumb. The Chicago observer thought that the line of writing should be about 30° to the edge of the desk, to secure free movement of the hand across the page. The better writers spend a longer time on pauses than the poor, and young children than the older. Arm-movement writing beyond a doubt is the only efficient writing. Unfortunately, the whole study, although in many ways most comprehensive, was confined to a comparatively illegible sloped cursive style of writing, and so lost much value for educational purposes.

Unseen Writing.—In some of the myope schools the children do unseen writing standing at the blackboard but looking away from it. Some do cursive, others print excellent script, written at a great rate and with well-formed letters. It is the form in which all children should learn writing. A quarter of a century ago we set out in Bradford that the child leaving the infant school ought to be able to write or print its name on the blackboard, in letters as large as its hand with its eyes shut, then there would be little difficulty in getting good writers without much copy-book work later.

It is also possible to write quite well without seeing anything of the pen-point. A paper shield 2 in. across has the pen thrust through it. A broad blue guiding-line on the shield helps the sense of direction. The blue is to distinguish it from the black writing.

The Written Product.—Apart from the ordinary school inspections the product of writing has been accurately examined. Empirical scales of goodness of writing have been set up by educators such as Thorndike, Ayres, Graves, Starch, Gray, and others. Various papers dealing with the objective side are found in the *Journal of Educational Psychology* in the first years of the War. Graves's paper in 1916, p. 483, sums up the subject well: testing speed, legibility, and other qualities by statistical methods; slant, classified by the angle; spacing and arrangement.

C. T. Gray attempted an extensive score card (*Univ. of Texas Bull.*, July 1915). He also measured the variations of pressure in children. There is, however, little really useful material in these examinations. On the other hand, by detailed criticism of the instruments, materials, and development, from the Roman capitals to the modern Civil Service style, Grailey Hewitt provides much valuable stuff for the educator (1915, *Handwriting*).

Writing can be enormously simplified if one gets clear of the feeling that the old sloped copperplate of the writing-master is the ideal. It is undesirable if only on the score of illegibility.

The student of writing will soon be able to analyse the requirements with which teaching must comply.

1. It must not make severe demands on vision.
2. It must not cramp the fine finger muscles, by requiring small accurate forms, or extreme variation of pressure.
3. It must, in the written word and sentence, preserve the same spatial relations as in the printed forms. This means the maximum legibility.
4. It must be able to be rapidly written, have individuality, be an artistic expression, and look well.

A common complaint against the writing of all children who are taught well is that it is lacking in any character. This is hypercriticism, probably made in ignorance of adolescence being the time when individuality in this respect declares itself. One recalls, too, the extraordinary parodies on vertical writing, popular in some girls' schools a generation ago, where letters six or seven times their height were joined by long slanting hair-strokes almost invisible.

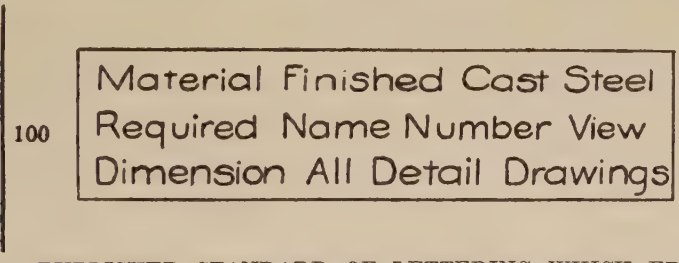


FIG. 113.—PUBLISHED STANDARD OF LETTERING WHICH ERRS IN BAD SPACING OF LETTERS AND THEIR DISTANCES.

Although this was almost illegible and all the same, yet some individuality came out on careful examination. The dreadful illegible handwriting of many able and scholarly persons results from teachers in the primary school age who thought more of Balbus and his wall than of usefully developing the pupil's power of graphic self-expression by well-formed letters.

The earliest beginning, then, should be with the kinæsthetic memory of letters; afterwards the printed word and its spatial relations. From the earliest stages spacing is the most important factor in legibility. Here is the 100 per cent. mark scale for measuring freehand lettering, published by H. O. Rugg, of the University of Illinois. It is a failure as a standard, beautiful as each letter shape is, yet many of the letters are too wide compared with printed letters, and the approach between the letters too small, detracting from legibility.

Many excellent school exercises fail in this matter of spacing. Some of the beautiful work reproduced in the pamphlet on script writing issued by the Child Study Society in London in 1918 had doubtful spacing.

The simple forms gain in legibility and speed if connecting strokes are wholly omitted for children. So far as the eyes are concerned the work is nearly halved, and it is also eye work that slows the writing. There is therefore everything to gain educationally from this script print writing, which abolishes the useless and time-consuming loops and turns.

The size of letters should be as large as possible. One would prefer for the learner of letter forms my old infant-class formula, "As large as your hand." When copy-books are to be used they should be at least half text, and whatever age the child no formal writing lesson should be permitted with letters less than about 5 mm., or one-fifth of an inch, in height.

The ruling of papers supplied by Education Authorities is found in a large and costly variety, occasionally harmful or unnecessary for education.

The paper for general school use should be plain, unlined, cream laid, or with heavy blue lines at 12·5 mm. ($\frac{1}{2}$ in.) intervals.

Where teachers required ruled papers for writing, then for any full text copies a double blue line might be used, plain bold lines 15·7 mm. apart. For half text, double lines 8·5 mm. apart at 17 mm. distance, and for small text 4·7 mm. apart and 12·5 mm. intervals. These should not be used generally, but for special purposes. Squared books are not desirable, but squares of 12·5 mm. ($\frac{1}{2}$ in.) side might be issued, and quarter-inch squares for teachers' use only. For graphs, one-tenth inch squares should be provided for ordinary school purposes. Logarithmic paper in millimetre squares is only necessary in laboratories where fine physical work is done, or for the teacher's own use for special records.

It is worth while modifying the pen-point to suit the simple script forms. A broadish point, not the fine pen-point which requires manipulation to give a good result, but a broad square point to save much finger-strain of the fine muscle movements, an average width of a millimetre, not more. Its down stroke will be even, thick and legible, its curves will thin and thicken mechanically in the right places without variations in pressure being a necessity. Good writing, as the author found after much experiment, can only be done easily and becomes beautiful with what Grailey Hewitt calls a quill cut broad. Loops and flourishes, which are marks of degeneration in writing, are almost impossible with the broad-pointed pen. It also maintains a good attitude of body in the writer.

Children tend to a spasmodic, cramplike work with the fine finger muscles, and are most easily exhausted if using fine-pointed pens. Almost any young child, instead of holding the pen with its index finger below the thumb, pulls this up level or possibly above the thumb, and bends the second finger-joint at an acute angle in its efforts, a practice which is a common forerunner of writer's-cramp (Fig. 112B).

Sir William Gowers, who had studied the neurology of writing very thoroughly, declared that if all persons wrote in a free method from the shoulder there would be no writer's-cramp. The mode of writing, however, is a matter of education, and the prevention of disease therefore rests with the teachers and not with the doctors. "It is probably impossible to teach writing in the first instance in a free manner, but before a boy is allowed to pass from school, he should be got out of the cramped and taught the free method—taught, that is, to write from the shoulder." This chapter suggests an educational method which removes all these ills from the very first, and advocates free methods throughout.

C. W. Kimmins, who studied writing in the London schools as Chief Inspector, found that the complete omission of a guiding-line, as advocated formerly by the writer, was disappointing in result. He thought a couple of lines were useful for the actual beginners, but should never go beyond the infant school. With teachers as educated at present some such orientation for the child is a necessity, and time saving in the earlier lessons, but if the teacher has faith in the child's learning by muscular sense instead of by vision he will in practical experience get better results without guiding-lines.

New York experience (1909) shewed that free muscular drills in writing movements gave such good results that the abolition of copy-books could be considered.

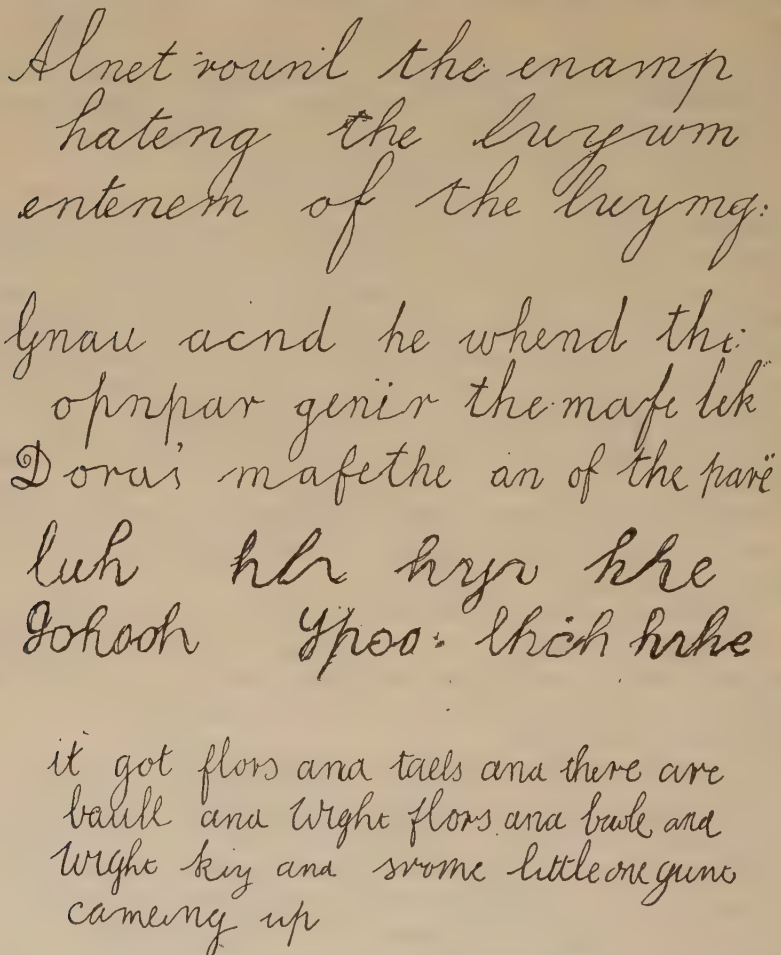
A definite attempt to eliminate visual writing for muscular will result in greater rapidity, better mechanical formation of letters, greater legibility, and be an aid in the preservation of good vision in our scholars, 10 per cent. of whom on leaving the primary school are now found myopic.

Unusual Writing.—The capacity for writing is very varied. As a general statement a considerable number of children are incapable of acquiring more than the merest rudiments. Many of these children have marked mental feebleness, others seem scarcely amiss in many respects. The want of literary ability is probably more general than is supposed; and these cases throw a very suggestive light on the comparative value of a classical training as the chief part of a system of general education, and the school failures who have been distinguished in after life (*Report*, 1904. 30). Failure to read and write to such degree that neither is generally useful, or used in after life, seems inseparable from about 10 per cent. of the elementary school population. Although in this direction the teacher's efforts are but wasted, little further notice has been taken of the fact by educationalists. It was one of the writer's chief reasons for suggesting a residential school of observation about 1905–6, the want of which since then has probably cost London many hundreds of thousands of pounds wastefully spent, not only

in providing for misfits turned out, but also on hopeless attempts at education.

The mode in which the very smallest children see symbols has already been noticed. It is worth more careful study.

Before school days intelligent small children are fond of mimic



F:G. 114.—THE FIRST TWO SPECIMENS ARE BY WORD-BLIND, THE NEXT BY A NEARLY IMBECILE CHILD, AND THE LAST FROM DICTATION BY AN INTELLIGENT HARD-OF-HEARING GIRL.

writing. It is a mere irregular wavy scrawl horizontally across the paper in nearly parallel lines. In later school life some children, generally mentally defective, produce similar meaningless scrawls, others make imitations more like letters, as in the third specimen in Fig. 114. This was done painstakingly in about 10 minutes by a girl of nine in an elementary school. Her brothers and sisters were no scholars and her mother could neither read nor write.

In a paper on "Young School Failures," Woolley and Ferris (*U.S. Bulletin*, 1923, No. 1. 15) refer to "Many of these children when they enter the class can not only copy script, but can copy in good script and with surprising accuracy whole pages of print, not one word or letter of which they can name. One must wonder in what curious images they think while working at what is for them altogether devoid of meaning." These are varieties of graphic aphasia (p. 621). The boy who wrote the first specimen in Fig. 114 was similar, in that he could copy correctly and neatly, does arithmetic well, and is a bright boy in all other respects. The specimen

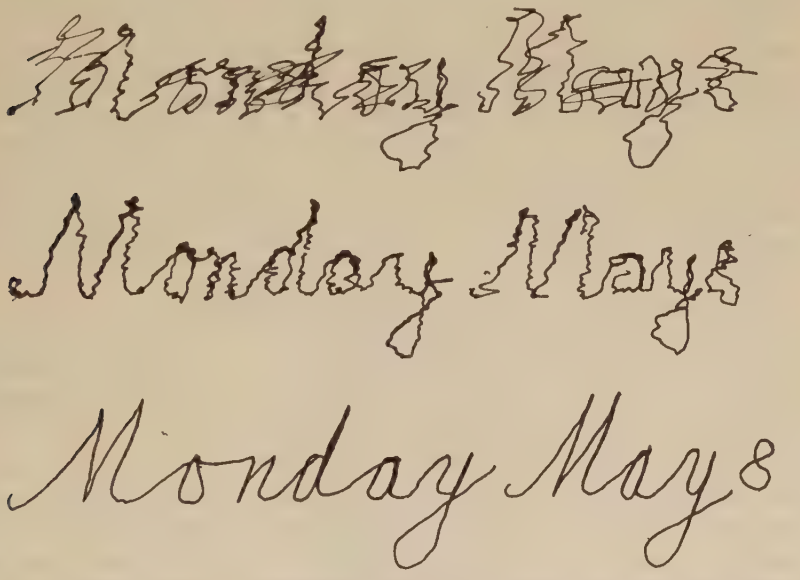


FIG. 115.—FUNCTIONAL TREMORS IN A BOY, FOLLOWING REMOTELY ON EXCITEMENT IN A RIOT.

The three specimens were written in the same quarter-hour, suggestive psychotherapy being used in the intervals.

dictated to him was "All round the ship hang the bright shields of the Danes." The next specimen is by a boy who cannot transcribe, copying from the board, "Just as he reached the open country he met little Dora's mother and the people of the village"; he has only caught "Dora's" correctly. The next illegible mass of letter elements was produced after much work by a mentally defective girl.

The last specimen represents an attempt by a hard-of-hearing girl aged 13, who later made good progress; it describes a Swiss valley scene with blue and white flowers and cows. Deterioration of writing may occur; whenever noticed the doctor's attention should be at once directed to it. The commonest variety is in the early stages of chorea, when treatment is all-important. Good

handwriting may deteriorate before any choreic signs shew; later the jerky irregular movements are shewn as scratches and scrawls, but at first may be controlled to some degree.

Various tremors may be noticed. It is chiefly a very fine, rapid movement in overworked and ill-nourished children, and is mainly functional. Functional tremor is not uncommon in women teachers. One sufferer learned to write a beautiful copperplate with her left hand. Sometimes it is part of writer's-cramp, then usually painful. In teachers, too, one must think of disseminated sclerosis. In one case this tentative diagnosis made on the writing changes was not definitely confirmed for several years. These disorders, however, can be left out of account in the case of children, except the fine tremor of hysteria. This condition was repeatedly noticed during the air-raid period among Semitic children, and earlier one boy who lived in Sidney Street developed it after the riots there. When first seen, months later, he was temporarily relieved by suggestion, and the figure is interesting as shewing the alteration produced by purely psychic means. The three specimens (Fig. 115) were all produced successively in the same quarter of an hour in the author's office.

Before restrictions were put upon the use of tobacco by juveniles some specimens were obtained by Dr. R. J. E. Hanson from small boys whose writing had become very irregular and uncontrolled. This led to enquiries and the detection of much cigarette smoking, with improvement in the writing.

Sometimes in older pupils dementia præcox may be suggested by the writing of letters with evidence of perseveration and the use of long words, or of neologisms and repetition of phrases. In dementia præcox there is occasionally a tendency to go back and touch up details, cross the t's, join up strokes round curves, and so forth, which is said to be characteristic.

Dr. Pietro Gonzales in Milan drew attention and furnished many specimens of her work in the case of a girl of 11 whose writing, deteriorating by fits and starts, first led to the discovery that the child was also mentally deteriorating (*Int. J. of S.H.*, vi. 430). The subject of comparison of a pupil's handwriting at different times is evidently worth considerable study, and may be found of considerable prognostic value in some cases of early breakdown.

CHAPTER XXVIII

HEARING

The ear is made up of various structures associated with nervous machinery which perceives any vibrations ranging from about twenty to 20,000 in a second. Lower ranges are felt by the ordinary nerves of sensation. Higher are not directly perceived.

Like the skin and nervous structures generally, these organs are mostly formed from the epiblastic layers of the embryo, and in degenerative conditions may share the common lot, so that certain structural forms of defect occur associated as general stigmata of degeneration, and may be hereditary.

The auricle, or pinna, is sometimes malformed, the lobe absent

Fig. 116.—THE LEFT MEMBRANA TYMPANI, SHEWING NORMAL CONDITIONS.

or adherent. The Darwinian tubercle is occasionally exaggerated. There may be a little persistent sinus, like the depression of a pin-prick in the front end of the helix.

The external meatus is not tightly fixed in its outer half. It slopes a trifle up, but the inner half is closely adherent to the bone and slopes a little down and forward. In all examinations or operations on the ear, it is important to raise the external ear up and back, so that the axis of the outer part of the meatus nearly coincides with the axis of the bony meatus. The thin tympanic membrane inclines toward the anterior and lower part of the meatus at an angle of about 50° or 60°.

A properly adjusted speculum will shew the membrana tympani,

and slanting down and a little forward, reaching to its centre, is the handle of the malleus ; at the upper part the prominent process shews, and then slants forward to a small darker patch of the tympanum, the membrana flaccida, which covers the area of the tympanum partitioned off by the various folds around the ossicles and sometimes called the attic, in which any suppuration is likely to be persistent. With a thin membrane, the descending process of the incus, which articulates with the stapes, often shews faintly through it parallel to the malleus handle.

If there is contraction going on in the middle ear, the handle of the malleus may be rotated so that it seems broadened. A congested

FIG. 117.—SECTION TO SHEW GENERAL ANATOMY OF RIGHT EAR.

1, Entrance to external auditory meatus; 2, on the head of the malleus; 3, cochlea; 4, the auditory nerve in cranial cavity; 5, carotid artery; 6, Eustachian tube opening in pharynx; 7, the inferior surface of petrous bone.

blood-vessel will occasionally be seen running up it. The condition of the membrane, bulging or indrawn, has to be determined by impression from the light reflex. The indrawn drum, with diminished or absent light reflex is often forerunner of progressive deafness.

The cavity of the middle ear or tympanum has openings on its posterior wall to mastoid antrum and mastoid cells. Through these sepsis may extend to the cranial cavity and lateral sinus. The floor of the tympanum is thin, just over the jugular dome beneath, another route through which there is risk of extension of sepsis. The anterior wall runs down into the Eustachian tube, which is only cartilaginous in the upper part of its circumference and partly fibrous, so that it easily collapses. It extends to the Eustachian opening behind the posterior end of the lower turbinate

bone, and on the lateral wall of the pharynx, above the level of the palate.

The mucous membrane of the pharynx is thus in continuity with the lining of the tympanic cavity, and this is the route through which sepsis extends in perhaps 99 per cent. of the commonest ear disease, purulent otitis.

Vibrations of air communicated to the drum are conducted and regulated by the chain of ossicles, with their muscles, and reach the internal ear. There machinery of the cochlea in some way analyses the tones. Connected with the cavity of the inner ear is the labyrinth by which sense of orientation is maintained. Disturbances extending to the inner ear are liable to affect these nerve endings and cause vertigo, or reflex effects in nausea and vomiting. Further details of structure must be sought in anatomical works, but a section is figured to display the chief relations of parts for reference.

Standards of Hearing.—As a physical instrument the ear is extraordinarily sensitive. Rayleigh got a tone of 2750 vibrations audible when the amplitude of air movement at the ear was only 0·00081 μ, a small fraction of wave-length of light.

Ordinary hearing being several times more acute than that necessary for the daily purposes of life, wide variation of sensitiveness occurs within limits taken as normal. Defect may unwittingly and progressively increase to considerable amount before becoming evident. Records of children killed in the street in many cases shewed variable deafness (*L.C.C. Report*, 1913. 36).

A physical inspection of ears should be made before any testing, as wax is one of the commonest causes of marked deafness. Deafness is itself only a symptom, which may be due to different diseases. Bezold, of Munich, used whispered speech as the best test of hearing in children. He found a forced whisper audible at 8 metres in 80 per cent. of ears tested, 12·6 per cent. heard between 4 and 8 metres, 8·13 between 2 and 4 metres, 2·65 between 0·5 and 1·0 metre, and 1·66 per cent. at less than 0·5 metre.

In determining a standard of hearing for Yorkshire children the watch test was abandoned and a forced whisper used. Testing was done in a rural playground of a good class suburban school, during quiet, warm summer days. The children, facing the observer, approached him along a chalk line marked in metres. They used both ears, and had to repeat three numbers correctly. All hearing at over 20 metres was considered normal. For healthy children the hearing distance appeared to be about 25 to 27 metres. If the eyes were covered, this distance was reduced by about 2 to 4 metres. The younger the child, the more acute its powers of hearing. In these children excellent hearing over 20 metres was found in 66 per cent. ; fair hearing from 12 to 19 metres, in 25 per cent. ; and poor

hearing, being less than 12 metres, was 5·5 per cent. All would have passed the Board of Education test of 20 ft.

These numbers are probably correct within 3 to 4 per cent. of their value. Hearing is so variable from minute to minute, and hour to hour, that it is impossible to be correct with percentages finer than whole numbers.

The hearing of good-class children can be inferred from Dukes's records among 1000 admissions of Rugby boys, only shewing Eustachian deafness 13, aural deafness 19, aural discharge 2.

Although the standards used may not have been quite the same, they form contrasts with Dr. Ivens's report on 1006 Whitechapel children, one-third of whom had some hearing defects and 72 aural discharge ; or with the 1000 Poor Law children at Hanwell whom Cheatle reported on, 88 of whom had aural discharge and 355 evidence of past or present suppuration, whilst 520 had defective hearing.

It is possible by listening steadily to a scarcely audible ticking of a watch or clock to realize the conditions of defective hearing in school, and how attentive hearing waxes and wanes when near the limit of audibility. The consciousness of a sound is a psychological matter. Some sounds are not noticed, although within hearing range. For this reason neither watch test nor Politzer's acoumeter are reliable with children. In young children they test brains rather than ears. Inexperienced observers of older children appear to get clear-cut statistics with such tests, but the results do not stand checking with other auricular tests.

Hearing is a primary function which may be damaged and deteriorate. The deterioration may be compensated, but the hearing cannot be improved beyond its original condition.

Physiologically, like the accommodation of the eye, hearing capacity is diminishing from the first day at school.

Balbi devised an electrical acoumeter whereby audition can be measured for any tone, in its vibration number and intensity. An indicator diagram can thus be prepared of the efficiency of every part of the hearing capacity (*Lancet*, 1925. i. 954).

Education by Hearing.—The improvement from training is due to better attention to the sounds heard, and their reference to previously formed associations, but there is no actual improvement in auditory capacity for single tones.

In Nature study, by training children to precision in description of sounds and their interpretation one can obtain as extraordinary results with normal children as with the blind. Sounds of slight intensity, chirpings and buzzings, rustlings and rushings, the myriad voices of field and flood, the finer tones and shades of speech, all build up a discrimination, of an epicritic character, on which the richess of an intellectual conception depends.

The part hearing takes in development of a young child's mentality has impressed many observers from the times of Aristotle and Hippocrates who classed deaf mutes with imbeciles, to Kant who thought the deaf mute could never attain to more than an analogy to reason, and Schopenhauer who assigned a deaf mute reason as a potentiality rather than an actuality. Congenital deafness is mentally serious. "The problems of deafness are deeper and more complex, if not more important than those of blindness. Deafness is a much worse misfortune, for it means the loss of the most vital stimulus," is the judgment of Helen Keller, whose genius has triumphed over both defects. The congenitally word-deaf formerly taken for imbeciles afford a rare but extreme demonstration of the part hearing plays in developing reason. Both Mumford and Berry have demonstrated the want of brain development to be inferred from cranial measurements of deaf mutes.

The superficial observer easily misses deafness, and indeed three-quarters of the cases of deafness in the curable stage may be said to be unnoticed by any but the careful tests which are impracticable in school. It is remarkable how deaf children can conceal their defect, and only be accounted stupid or dull.

The tests applicable with tones are commonly used in relation to children in deaf schools, but are rather of the specialist's armamentarium. Special test tuning-forks have to be used, loaded to get rid of overtones as far as possible. The stem is also provided with a foot for application to the skull. The normal limits of audibility for tones lie between those of 20 and about 20,000 a second, but the useful limits for speech are comprised between 120 and 520 a second. If a single fork is used, probably A′ is the most generally useful for testing purposes, C′ of 256 vibrations is also popular. With a series of graduated forks islets of hearing may be determined as shewn by Bezold and Dr. Kerr Love. Any of these islets falling within the speech range are valuable for training purposes. For other purposes *Schwabach's test* may be used. The time during which the fork is heard by bone conduction is much shortened in inner ear or nerve affections and lengthened in middle ear or conduction deafness.

Rinné's test compares the air conduction with bone conduction. For the A′ fork, bone conduction is about 30 seconds shorter than air conduction, so that if the fork which has become inaudible when held on the mastoid is quickly held to the ear, it may be heard again by air conduction. This is called a positive Rinné and indicates that hindrances to sound conduction exist. If, however, the sound, after ceasing to be heard on the mastoid, is not heard again by the ear, the air conduction is diminished corresponding to the bone conduction, and it is spoken of as a negative Rinné and indi-

cates hindrance to sound perception, that is probably inner-ear disturbance.

Weber's test with the fork on the middle line of the skull to determine which ear has best bone conduction is rough and not reliable.

Many painstaking surveys of children's hearing in the primary schools of numerous cities and districts shew that 25 per cent. have some hearing defect, and that for 5 per cent. it amounts to an educational hindrance. The testing of hearing may be done with regard to its (1) practical value for educational purposes, or (2) prophylaxis of deafness.

For children, the whisper without the child seeing the observer's face is best.

Uniform results are obtained by breathing out gently and then using a voiceless forced whisper with the residual air. The best test words are the numbers below a hundred. Sibilant sounds are easily heard—for instance, "sixty-six"; on the other hand, a number like "twenty-three" appears very difficult. Gradenigo determined the standard hearing distance for the vowels with forced whisper as—

a	e	i	o	u
26	38	34	25	11 metres.

Only practice aids one in using test words advantageously.

My experience in determining the standard distance shewed that testing of children's hearing in school from the aurist's point of view, to secure early cases for treatment, was almost impracticable. The natural standard of 25 metres had to be reduced. Bezold took 8 metres, Cheatle took 18 ft., because there was a suitable room. The Board of Education at first (1908) notes the difficulty of school testing and stated, "such a proceeding can hardly be necessary." However, they gradually came round in the next four years to "emphasize the view that a suitable hearing test should be applied to every child inspected." The forced whisper at 20 ft. for each ear separately was enacted (1912). Educationally, the testing of each ear separately is *de trop*, and for prophylaxis the testing at 20 ft. misses the majority of early cases. Probably if schools were compared together on this test, the difficulties of school testing in towns are so great that the massed results would chiefly be determined by school rather than aural conditions. The main thing, however, is a step forward, in that all children's hearing is now tested in some kind of way, although there are such published results as the County of Northampton, where "The existence of ear disease and deafness is represented by less than 1 per cent. among entrants and leavers in each case" (*Report*, 1914. 20).

It would be valuable for the public health and for education if

hearing tests had to be done by teachers. They are often unaware of deafness, and seem to take little interest in it.

Van der Wal, who reported on 7433 Amsterdam children, noted that of 494 reported deaf by teachers only 233 suffered, whilst 569 deaf had not been noticed in school. Of 42 who could not hear at 0·5 metre, and who required educating as deaf, 22 were said to be stupid by their teachers, and only 7 known as deaf (*Ned. Tyd. v. Genees*, 1914. 697).

In Boston, where the teachers test children with their backs turned to the teacher, they return between 8 and 9 per cent. as deaf or hard of hearing. In America it is in many places a regular part of the teacher's work. The testing by both teachers and doctors is strictly comparable. Denker, at Erlanger (1906), with thousands of tests, found teachers return 5 per cent., the doctors 4·6 per cent. as deaf. Bezold of Munich and Hartmann of Berlin, after extensive experience, recommend teachers for this work. It is not work that requires medical knowledge, or scientific training beyond any teacher's range. It also gives experience and knowledge which will influence the teacher's educational work.

Mistakes in dictation, in spelling, or oral arithmetic are often due to bad hearing. Sometimes children will be noticed to bend the head or turn one ear always to the teacher. Sometimes they watch the teacher's face constantly. Indeed, some sharp, hard-of-hearing children will prefer to sit on the back row and lip-read the teacher, getting away from the strain of a confused voice. Some seem to be always repeating a question to themselves. Once their attention is drawn to these manifestations, teachers can soon develop a technique for handling the children.

Defective hearing as a symptom in the pre-school child is of the utmost importance, as the fatalities from ear disease are much higher then than at any other age

Simon attempted a kind of scale for testing hearing by falling objects, but for the pre-school ages recognized that spontaneous response was the only test. A game whereby an infant was called out of its place was used, and response to its whispered name also became a valuable test of hearing. A similar method has been used in Chicago by putting a suspected child in different rows of the class and then testing him unawares, whispering his name, or calling it in a low voice.

Minor Ear Troubles.—The external ear may be the seat of different unhealthy processes, impetigo, and so on. The commonest is eczema, either of the pinna or external meatus. The affected surface should be washed, dried, and painted with a 5 per cent. solution of silver nitrate and then some simple ointment used. This may have to be repeated several times.

The syringing of ears is often done ineffectively. To remove

cerumen, for instance ; this should be softened by the use for a few hours of a weak solution of washing soda, or at the time by the instillation of some drops of hydrogen dioxide solution. In syringing, the pinna should be drawn about a quarter of an inch up and back, and the jet of the syringe directed upwards about 20° to 30°. Foreign bodies may sometimes be syringed out. The use of probes or hooks is dangerous except in experienced hands, but syringing can do little harm. If there is swelling or the foreign body is impacted, great care is to be taken. An aurist may even find it necessary to incise the meatus from behind the auricle or chisel the bone. In inspecting ears, foreign bodies are sometimes met as cause of chronic discharge. Tuberculous disease of ear and temporal bone, whilst met with in infants, is so fatal that it is very rarely seen at school ages.

Discharging Ears.—Commonest of aural conditions is suppuration of the middle ear. This may be the result of acute catarrh due to infection from the Eustachian tube as a part of a cold, influenza, or one of the zymotics. The condition may be subacute, and end in perforation of the drum and chronic discharge. It is common in pre-school ages, and then seems to be easily recovered. Examination with a speculum shews many children with the scars of perforations on the drum, but little deterioration of hearing. Others present cicatrical changes and thickening that leads to impairment of hearing. Even at the stage met in school probably three-quarters with chronic discharges could recover with fair hearing. The cases with scanty discharge and a horribly offensive smell are particularly serious, as this often means cholesteatomatous formation having set in.

Discharging ears are a bugbear of school-life. They should be uncommon. Aural surgeons in large practice may operate on twenty charitable cases of mastoid disease to every one on a paying patient. To avoid a bad result for hearing, most cases of earache, and every case threatening acute otitis, especially scarlatinal, should have paracentesis before the membrane gives way. When purulent otitis has become chronic it is a constant source of risk. The Board of Education call it a minor ailment. The writer's early experience led him to describe a neglected discharging ear as about as risky to life as carrying a dynamite cartridge about in one's pocket. Dr. Stewart, of East Suffolk, reports that of five children whose parents had been warned of the possible dangers of delay in obtaining treatment, recurrence of inflammation occurred necessitating . . . operation for abscess of brain. In two of the cases death resulted (*B. of E. Rep.*, 1911. 45).

No judgment should be passed on a case unless the ear has been thoroughly cleansed, dried, and inspected. No case for which one is responsible should be passed over till this has been done.

A safe habit is to make a rough sketch of every ear drum, with a note on light reflex, appearance of malleus handle, and any vessels, granulations, perforation or discharge. This avoids mistakes easily made, even with a speculum and good light.

School Treatment of Discharging Ears.—In young children this problem is not yet fully appreciated. By daily treatment of a considerable number, the writer personally tested the possibilities. The treatment was a conscientious cleansing and drying of the meatus and middle ear with boracic powder, alcohol drops, and so on. Throat conditions were remedied and granulations cauterized. For months the wearisome task was persevered with as an experimental enquiry. It shewed that although many easily relapsed with the next cold or damp weather, about a third rapidly recovered, another third made a tardy improvement, the rest seemed chronic. It was deemed that a case which resisted such treatment for six or eight weeks needed opening up through the mastoid. After operation, the improvement of hearing was occasionally remarkable. What stood most in the way of ordinary relief was the want of frequent treatment in school itself. Treatment twice or thrice daily is most efficacious in the school, as Dr. Mailand has shewn by the work of nurses in the Hard of Hearing School at Copenhagen, where two-thirds of the patients suffered from chronic purulent otitis. Dr. J. Kerr Love, in Glasgow, has insisted on the importance of treatment in school as better than at hospital.

An experiment carried out in 1909–10 by the L.C.C. through Jubilee nurses visiting at the homes, shewed that treatment there gave results in no way commensurate with the effort or cost (*M.O. Ed. L.C.C. Report*, 1911. 94). Still this treatment was most useful as selective in demonstrating the cases which required surgical relief. Each deaf school requires its own school nurse in daily attendance. A nurse's room must be provided.

Ionization.—Zinc ionization advocated by Dr. Friel has opened a new chapter. Whilst an acute otitis is generally due to a single organism, ordinary chronic discharge is kept up by sepsis due to a multiplicity of organisms infecting the discharge. The cause of the chronicity may be polypi, or granulations, or pockets of pus, which do not drain. A perforation of Shrapnell's membrane suggests sepsis, in the many recesses of the membranes about the ossicles, in the tympanic attic. Where the sepsis is purely tympanic, as it is in about half to two-thirds of the cases, ionization may be expected to give a rapid and good result. Effort should therefore first be made by treatment of all accessory causes to reduce the trouble to tympanic sepsis. A most careful and thorough toilet of the middle ear has to be carried out to get rid of every scrap of discharge. The sepsis is confined to the discharge and to the surfaces in contact with it. If the discharge is replaced by a dilute

solution of zinc sulphate, the surfaces in contact with this can be sterilized by passing weak electric currents.

Toileting of the ear is by syringing with warm water. If necessary one may use a drop or two of cocaine solution before wiping out adherent discharge. The last remnants are best removed by ether on a pledget of cotton-wool about a probe. Siegel's pneumatic speculum will shew if any pus can be drawn from the mastoid antrum, attic, or Eustachian tube. The zinc solution is then run in. Its strength is zinc sulphate 4·5, glycerine 60, water to 1000. An effort must be made to get it in contact with every part of the septic surface. Special means of doing this may have to be used. The child is laid with the affected side uppermost, a special speculum is inserted. It has an electrode ending in a cotton wick which dips into the fluid in the meatus. The other end joins the positive pole of the electric supply. The indifferent electrode, a metal plate over a towel moistened with salt solution, is strapped to an arm or leg. The current is slowly turned on and raised to three milliamperes, at which it is kept for ten minutes, and then slowly reduced to zero. If the mains are used, precautions must be taken to safeguard against any shock, and any sudden change of current, as this may cause vertigo, nausea, or vomiting. After ionization the whole surface in contact with the fluid will be covered by a sterile greyish-white film of coagulated albuminous material. A little boracic powder is insufflated, and the ear left alone for a week, when it should be dry and well.

For complicated cases repeated ionization may be needed, and further treatment of polypi or granulations. If definite improvement does not result, surgical operation is necessary. Friel's experience is that half the cases are readily cured, a quarter with some further trouble, and a quarter have to be referred for operative handling.

With an efficient technique this method is an enormous advance. Even here when the ear has been sterilized and remains dry, fresh attacks may easily follow neglected colds or as a result of bathing or diving with unprotected ears. Jobson sums his experience that ionization will cure any case curable by drops, that it will do it in a hundredth of the time, and that it will cure a large number unrelieved by ordinary treatment (*B.M.J.*, 1924, i. 371).

CHAPTER XXIX

THE DEAF CHILD

Causes of Deafness.—Many classifications of the causes of deafness are possible. For prophylaxis we want to know which are preventable, for treatment which are improvable, and for educational purposes what the outlook is for later hearing.

About a quarter of school children have hearing which is subnormal. The early investigators, Barr (Glasgow, 1890), found 27·66 per cent. defective, Bezold (Munich, 1885), 25·8, Denker (Erlangen, 1906), 23·3. These results are examples of hundreds of enquiries. Bezold thought that in the ordinary school child, with hearing defect, atrophy and thinning of the drum was the cause in 48 per cent., and acute or chronic suppuration 7·4, whilst 29·8 shewed nothing obviously wrong.

For our purpose analysis of 1863 pupils in L.C.C. deaf schools, compiled by Yearsley in nine years up to 1917, gives a survey of causes of the deafness needing separate educational provision in Table 82.

The variations between boys and girls, or in various schools and towns, are considerable, and depend partly on amount of selection for deaf education. New York returns three times the proportion due to meningitis, and only one-third the amount from measles, compared to London results. Our congenital cases represent 36 per cent. against 30 in New York.

Probably at least half the cases of all forms of deafness are preventable. If subnormal hearing in ordinary schools is reckoned, then 80 per cent. should be preventable.

If only half the cases due to measles, and half the scarlatinal cases, and those due to neglected adenoids, were prevented, it would reduce by one-third the numbers in London.

In New York schools 30·6 per cent. were born deaf, 30·4 became deaf in their first three years, 23·1 after this, but before their sixth year, and only 16·0 per cent. after the sixth year. Evidently prevention must be early, in pre-school or nursery school-days.

At those ages the most obvious sign, and one which no teacher should neglect in any school, is mouth-breathing. The writer's first extensive enquiry was the selection, from a distance, of obvious mouth-breathers, in a playground march past, after exercising, and

in the month of June when catarrh was at its lowest. They varied from 17 per cent. amongst the six-year-olds to 7 per cent. at ten-years-old, the average being 10 per cent. Of those selected as mouth-breathers 14 per cent. were found with discharging ears, of the remainder only 1 per cent.

TABLE 82.

	Boys.	Girls.	Total.
I. Congenital—			
Hereditary	38	36	74
Sporadic	306	265	571
Aphasic	6	3	9
	350	304	654
II. Acquired—			
(*a*) Infectious—			
Diphtheria	10	10	20
Measles	73	57	130
Scarlatina	53	59	112
Other zymotics	15	14	29
Pneumonia	16	11	27
Congenital syphilis ..	30	50	80
Tubercle	6	4	10
	203	205	408
(*b*) Primary ear disease—			
Middle ear catarrh ..	112	120	232
Middle ear suppuration	118	96	214
Otosclerosis	1	1	2
	231	217	448
(*c*) Nervous—			
Cerebro-spinal	3	5	8
Other meningitis ..	97	80	177
Hydrocephalus	2	1	3
	102	86	188
(*d*) Other causes—			
Injury	45	25	70
Doubtful	54	41	95
	99	66	165
Total of all	985	878	1863

In Miss Ivens's records of 1006 Whitechapel children the mouth-breathers had 15 per cent. discharging ears, and the others 2·8 per cent. Of those who had discharging ears 78 per cent. were mouth-breathers, of those who heard well 34 per cent. (*Report*, 1907. 25).

Suppurative otitis in most cases, and in all mouth-breathers, may be set down to sepsis from the pharynx transmitted through

Eustachian tubes. Even in acute otitis of specific fevers this plays a large part, for mixed infection tends to chronic otitis. This is often avoided by attention to the condition of drum head, and early paracentesis, aural troubles generally ceasing with the relief it affords. No one ever regrets making acquaintance with this operation.

About equal in number to those with discharging ears are catarrhal non-suppurative cases which progress insidiously, and whilst causing partial deafness in childhood, result in much inefficiency in later life. The remedy for this is prophylactic treatment of the naso-pharynx, by removal of unhealthy conditions there.

One feature which the school can only indirectly influence is brought out by Kerr Love, that the deaf child is also the offspring of the one-roomed tenement, and all the neglected disease which this connotes. Yearsley remarks of London deaf children that they are of lowly station in the social scale. The aspect of defective housing thus made evident spreads widely in its effect on childhood, although not usually so easily demonstrable.

Congenital deafness accounts for 35 per cent. of cases in the London special schools, 31 per cent. being the sporadic variety not hereditary although congenital. Kerr Love thinks this variety tends to die out, and that it is remotely connected with syphilis. There are a few cases which are hereditarily defective in respect of epiblastic structures, so that mental defect, retinitis pigmentosa and deafness are associated (Shoemaker, *Retin. Pigmentosa*, Lippincott, 1909).

Somerville Hastings suggests that congenital deafness should be made notifiable. London deaf schools number about 4 per cent. of hereditary cases, the mass of which have no other defect. Kerr Love estimates hereditary cases as about 15 per cent. of congenitals, but London ones are little over 10 per cent. Hereditary deafness appears a Mendelian recessive, and probably 10,000 people in the country not themselves deaf may yet be able to transmit it. It is intensified by consanguinity in parents. The true test of heredity is possession of deaf-mute relatives, and it is often in collaterals that they are found. Although its heredity is well known, nothing is done to prevent this deafness. "We've four generations of born deafers, and all on the Missus's side." In 17 families with one parent congenitally deaf, of 69 children 21 were deaf-mutes; and in 9 families with both parents of this class, of 25 children 15 were born deaf. By promoting marriages "Deaf Institutions" and religious "Missions" are most mischievous agencies in this respect. As civilization advances it will protect itself against the hereditary deaf mutes by sterilizing them before puberty. The effect of heredity when coupled with consanguinity was shewn by Graham Bell for an isolated small village of Chilmark, on an island, Martha's

Vineyard, in which he found much intermarriage and 72 deaf-mutes. The population of the village I have not been able to determine. On the other hand, Yearsley quotes the remote St. Kilda, where there is much intermarriage but no deaf-mutes for generations, as shewing that consanguinity alone is not a cause when the other strain is absent.

Educational Classification.—Since Ponce de Leon educated some Spanish grandees in the sixteenth century, it has been known that where deafness was the only trouble deaf-mutes could be taught to speak.

The Education Act of 1870 in England only considered the normal child. Certain classes of children were evidently unfit for the ordinary school, and the first special legislation was the Education (Blind and Deaf) Act of 1893. This has been replaced by sections of the Education Act of 1921. It is the statutory duty of an authority under Section 52 (1) of this Act of 1921 to provide for deaf children, and the same section states that deafness is not to be a valid excuse for non-attendance except for those under the age of seven.

A very elastic definition remains in Section 69, that "deaf" means too deaf to be taught in a class of hearing children in an elementary school. This becomes the criterion of educational classification. About 4100 pupils deaf and 1600 partially deaf—these last are many too few—are now under instruction in England. Children must be medically certified for admission, and under the Regulations there has to be provision for their examination by a medical practitioner possessing special experience of their defect.

Bezold thought the child who heard a forced whisper at 2 metres had sufficient hearing for ordinary school. This corresponds to speaking voice at a half-metre, and it would seem almost impossible for a child with that hearing to keep up with ordinary school-work.

The primary consideration is that the deaf child should be educated in the highest grade of work which hearing permits. For education, its capacity means not only the sensory perception of sound by the ear, but also its apperception by the cerebrum. The great mass of children handicapped by subnormal hearing are able to make progress in the ordinary class. For education they are not deaf. If the Board of Education standard of a forced whisper heard at 20 ft., or 6 metres, is accepted as satisfactory, they are nearly all "normal." Slight deafness would be the forced whisper at 4 to 6 metres, medium deafness at 2 to 4 metres, and bad deafness below 2 metres. The bad are then certainly deaf for the purposes of the Act.

Hard of Hearing children who only hear the forced whisper at a metre, if highly intelligent, may progress in the front row of an ordinary class. A ten-year-old girl submitted as deaf, failed with

ordinary conversation, but heard the raised voice at a yard. She had been admitted to a secondary school, presented excellent speciments of written work, and was reputed "good at algebra." She was allowed to remain at school and maintained her progress.

If not progressing, or of merely average or even subnormal mentality, they are "hard of hearing," and should have special instruction in lip-reading, continued observation, and if necessary treatment as members of a hard-of-hearing class. Some of these will improve to pass back to ordinary school-work.

The Semi-deaf are the children who hear easily, and after a little experience can distinguish the elements of speech or even words or sentences spoken into the ear. They usually have lost their hearing from acquired diseases during childhood, and often present residua of old suppuration in the ears; sometimes they have islets of hearing, that is, they may hear notes of a certain number of vibrations, but not others. If the islet happens to fall within the range of tones over which speech extends, it is useful for educational training. These islets do not appear unless tested by a continuous series of tuning-forks; but as the useful islets respond to the ordinary voice, if tested carefully the speaking voice elicits what is possible. Once attention is deliberately turned to sounds the apperception may be improved. They seem more intelligent, and their voices are more pleasant than other deaf children. Sir R. Paget has shewn that vowels are made up of two tones, and reproduces them artificially (*Proc. Roy. Soc.*, A, 102. 353). The partially deaf, however, may only hear one of these tones.

The Semi-mute are children whose hearing has gone after they began to speak. Having no hearing, they are slowly losing speech. They probably already have the toneless "deaf voice." They will become mute unless special educational means are taken to preserve and develop the remaining speech. Like the semi-deaf, some are due to residua of suppurative processes, but in their case no useful hearing remains. In addition, many are the result of meningitis and nervous troubles.

The Deaf-mutes are children who are either congenitally deaf, or became deaf before speech had permanently developed. In their case development of speech in school is an extremely difficult process and depends on mentality.

Educational Provision.—Deaf schools may be residential or day schools. Residential deaf schools should be reserved for the class of cases with combined defects, that is, cases which are blind or semi-blind, or who are mentally defective as well as blind. A residential school of another character on the pure oral system may also be of use for scattered districts, or children from remote places. In these schools attempts are made to develop oral speech and lip-reading, but all methods have to be used, as many of the

pupils cannot benefit by pure oral training. Small classes, limited to ten pupils, are necessary.

The deaf children with combined defects of either blindness or mentality are a very difficult class to justify expenditure. The outstanding cases of Laura Bridgeman and Helen Keller are extraordinary exceptions. The Education Authority has the duty of providing education, if they are educable, and this can only be properly done in a residential institution. As each child has to be almost individually treated, they can all be received in the same residence.

The cases due to congenital syphilis often present combined defect in deafness and poor vision from old keratitis, sometimes they are also mentally dull or epileptic. As a rule they belong to the second half of school-life, and whilst medical treatment is of benefit, it is usually disappointing so far as hearing is concerned. The writer has only once seen a completely deaf child recover good hearing under most energetic early antisyphilitic treatment. The cases in the London deaf schools assigned to this cause number about 8 per cent. Kerr Love has pointed out its great social importance in his writings.

In a well-populated district where transport is good the best system of education for the deaf is day school. Children either live at home, or in particular cases are boarded out.

On admission to the school the usual medical notes have to be made. There must be a careful record of conditions of the ears, nostrils, and nasopharynx. The history of the case may affect the prognosis, and both family and personal history should be recorded. The degree of hearing is important. Is there any response to hearing? Does the child hear a bell? A standard form of bell with the clapper on a spring to give one stroke should be used. Can the child hear vowels—or words? The teachers will probably be able to determine the exact extent of hearing in the first two or three weeks better than could be done at the child's first examination.

The importance of vision being so great, the refraction should be carefully estimated, and any corneal defects treated, as sometimes the judicious long-continued use of yellow ointment improves vision.

The field of vision of deaf-mutes is more extensive than normal. They are more attentive, and visual acuity is sharper than others in this respect. This attentive vision is so marked that its absence is noted as one of the signs in the malingering of deafness. Although myopia is uncommon, vision must be conserved by avoidance of considerable close work such as sewing.

Speech Training.—Before speech there was gesture. In the animal and young infant gesture is the means of communication.

In deaf-mutes, or in others who early have interference with speech, gesture remains, or in the end they are likely to revert to it. All deaf persons subconsciously use some lip-reading, if only as observed gesture. Small classes are necessary, not exceeding ten, and good lighting of the speaker is essential in all deaf schools. There must be enough fine shadow to display the movements in articulation, but heavy shadows are to be avoided. Top light is almost an essential, but it must not be all top lighting, nor is direct sunlight an advantage. For artificial lighting, semi-indirect is the best, and on a plane 1·5 meters from the floor should never be less than

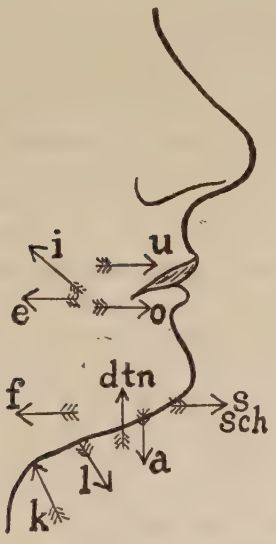


Fig. 118.—THE FIELD OF OBSERVATION IN LIP-READING.

5 foot-candles. Wholly indirect lighting would be troublesome and fail to give sufficiently distinctive shadows for good lip-reading.

The vowels are largely read from the shape of the mouth, but there are movements followed : (i) the underjaw ; (ii) the soft parts of cheeks and lips ; and (iii) the floor of the mouth. The movement of the underjaw upwards without closure of the mouth gives *d*, *t*, or *n*, with closure of the lips these become labials, *b*, *p*, or *m*. The movement of the underjaw forward is seen with *s*, and if the lips are also pushed forward this gives *sch*. A movement of the jaw back is made for *f* and *w*, and downwards for *a*. These three fields are represented in the figure.

The Mentality of the Deaf cannot be tested by the Binet and Simon Scale, which needs much language. Pintner and others attempted to compare the mentality of the deaf and normal children in respect to form board, memory span for figures, and other tests

(*J. Ed. Psych.*, 1915. 591). Deaf children at all ages averaged below hearing ones. They find that oral pupils are about two years, manual about four years, retarded. Some 3·4 per cent. are supernormal, 23·7 normal, and 40 per cent. may be called dull.

Dr. A. C. Williams, in London, found that the retardation was chiefly in visual memory, and that for most of the other tests applicable (copying, counting, fitting, etc.) there was no consistent difference with hearing children (*L.C.C. Rep.*, 1920. 49).

The symbols in thinking are words. These words represent a combined group of—

(*a*) Auditory impressions.
(*b*) Visual impressions and memories.
(*c*) Kinæsthetic (eye and articulatory movements and gesture).

Those who are deaf before speech is acquired do not possess the first (*a*) group, and thought has to be managed with the impressions (*b*) and (*c*). The oral method uses both, and those who have not been thus educated have only the kinæsthetic memories, and thought is likely to be laboured and slow. Congenitally blind are later in speaking than others (Nadoleczny).

Thought has to be developed in the child and its communication to or from others. Education aims at the child taking its place not as a separate, but as an integral part of the community.

The group (*a*) being excluded, it is a mistake to rely entirely on group (*b*) and strive to exclude (*c*). In order to get facility the pure oral system should be followed at first, and later in the child's life every means possible. Adult deaf almost always advocate the use in everyday life of combined methods.

The semi-deaf or semi-mute children can be aided by mechanical means, and every child who does not get pure sounds should be so aided. A sensitive flame, for instance, which dips to a certain vowel can be used. The teacher sounds the vowel, perhaps $\bar{a}$; then each child in turn. To the correct sound the flame dips, to the incorrect it burns steadily.

The use of hearing-tubes for several children with binaural earpieces can be utilized from a common resonator into which the teacher speaks. More recently, the microphone and valve amplifier offer possibilities.

F. G. Barnes, who has had an unrivalled experience of difficult cases, points out that whilst the oral system is best, the poorly gifted are unable to use it freely.

It is regrettable that we have no Research Department at Whitehall to investigate these and other problems that a local authority will scarcely touch.

"There is great need in handling an enormous mass of children of some central residential school, where certain children can be

tested and examined from day to day by the most accurate and reliable means, so that the influence of all factors on school life may gradually be worked out, and the possibilities of education in any doubtful case can be arrived at by quicker means than years of possibly misdirected energy in teaching" (*Report to L.C.C.*, 1904. 33).

As regards the oral system, Kerr Love regards the London scheme as the best anywhere, but Yearsley judges it as a comparative failure. Not half of those entering without speech ever attaining oral success (*Lancet*, Feb. 25, 1911). In later life the evening schools shew that 50 per cent. of totally deaf use no speech (*B. of E. Report*, 1911. 183).

Barnes points out how systematic teaching of articulation makes many children apparently less deaf. The objection that attempts at auricular education will interfere with lip-reading is only partly true. All senses must be used to the fullest, especially when the intelligence is poor, although progress may be slow.

The children who are now termed *hard of hearing* benefit by articulation lessons and lip-reading. They are a very heterogeneous group worth much detailed study. All possible methods should be used, and treatment be followed out. Hard-of-hearing children are about ten times as many as the deaf, and almost all improve rapidly in hearing, mentality, or scholarship. J. E. W. Wallin has drawn attention to the number mistakenly assigned as mentally defective and sent to special classes. Psychical deafness may be considered a form of aphasia.

Berlin, which originated these classes, made much of singing in education of the ear, although the methodical ear exercises with which they started were soon abandoned. The hard of hearing are not normal psychically. They are often very timid and apprehensive from repeated misunderstanding. London began such classes about 1909, and every class inaugurated gives complete satisfaction, but many more are needed. Yearsley notes that inattention, if continued, in school is due to aural or mental defects. The relief to the child by transference from the ordinary school, where fatigue alternates with the strain of attention, is marked. The pupil who often in school gives up the attempt to follow, and becomes careless and indifferent, now awakens. A new interest and an inquisitive thirst for knowledge are seen in the hard-of-hearing class. The whole tone of the class gives evidence of this changed attitude of the children.

The Act of 1921 does not compel deaf children under 7 years of age to be in attendance at school. The great hope for the deaf-mute is very early education. During the period when gesture is being replaced as a means of communication by speech, that is in the second year, is the psychological time for education of the deaf-

mute in lip-reading. From 18 months old till the age of 3 years the child is endeavouring to get into touch with human society, and neglect of this formative period can never be wholly made up in subsequent education. For many deaf children the years 5 to 7 are almost lost educationally.

Various hints to parents of deaf-mutes have been published. Good examples are the pamphlets by Margaret Martin (Glasgow Deaf Children's Society), and in America by J. D. Wright (F. A. Stokes Coy., 1915). The mother should train the child to normal life by imitation ; to look at her face when she speaks. She should not make signs, but talk. On no account should she attempt to make the child talk, or it will probably acquire faults difficult to eradicate in school later. Here, again, the pre-school age may make or mar the child's future position in life. Somerville Hastings, surveying the outlook in deafness, says that its causes must be tackled. These are : (1) poverty and all that it implies ; (2) catarrh, through overcrowding, unsuitable diet, and faulty environment : open-air nursery schools for toddlers and open-air schools for older children will help to prevent this ; (3) tonsils and adenoids, which probably cause 90 per cent. of ear discharge in children. Operative removal should be decided upon directly any middle-ear symptoms develop. Some local education authorities fail to fulfil their duty in this respect ; (4) nose breathing must be insisted upon, and proper breathing exercises carried out in school (*Journ. R. San. Inst.*, 1925. 185). Where there is a sufficient population, as in London, special schools for older deaf boys and girls are possible : schools where they are to be adapted to life. They should, if possible, continue till 18 years of age. Special whole-time courses can be arranged for those up to 18 under the Regulations.

The occupational hindrances from the aural standpoint may be classed as meteorological or climatological, where there are rapid changes of temperature or humidity. Many outdoor employments or such occupations as laundry work would therefore be put on one side. Dusty work and certain chemical occupations, even tobacco smoke, may affect some Eustachian cases. The constant noise of boilermakers and machine-shops, telephones, and so on, may accentuate tinnitus and deafness, although many of the most inveterate cases of dry catarrh hear better in noise.

The occupations boys may prepare for are cabinet-making, joinery, shoemakers, tailors, photographic processes, graphic arts, printing, and architecture. They are said not to do well with metal work, and are of little use in agriculture or on roads and among traffic.

Girls can be prepared for many domestic occupations —cooking, tailoring, dressmaking and millinery, bookbinding, cataloguing, and librarian's work might be suitable. They all should have a

good deal of physical exercise with hearing children. They should play all the ordinary games—ball games, dancing, skipping, running. For the smaller children blowing bubbles would be quite useful to develop their chests. They are seldom great readers, but like play with objects.

Those actually deaf are well looked after educationally ; it is with the potential deaf cases in middle life that the school time can be used for prophylaxis, and this should be the next advance, as in most, later conditions are hopeless for relief.

CHAPTER XXX

SPEECH

Speech.—The development of the brain in the animal series, and the attainment of superiority by the higher animals, has already been described. It is due to the intercalation of association neurons between the projection systems of the sensory receptors and the motor affectors. These association neurons give the power of storing the memories of experiences, and on this capacity the possibilities of education depend.

Brain development attains its highest form in the human being, where in two regions the supra-granular layer of the cortex excels in mass and differentiation. These two regions are the posterior association region about the sensory receptor projection areas, and the anterior association region of the purely human prefrontal cortex. The anterior apparently controlling the highest thought processes (speech content), as it suffers most in dementia, whilst the posterior association sphere remains functional (speech form).

These regions about the projection systems of the retina and cochlea appear to be concerned with storage of the memories needed for symbolizing things and actions by words. Whether any animal, except man, reaches the power of using symbols of any kind is doubtful.

The highest type of monkey is said to associate the use of two things only, if they are seen in the same field of vision. A bird will push or roll an egg back into its nest if it is only an inch or two off, but remove the egg several inches, and it merely becomes a part of the landscape, over which the bird will hop without any concern. Yet many animals and the infant shew distinct powers of appreciating the gesture of the moment and fleeting appearances of feelings.

Facial expressions of various emotions have been developed into the movements of muscles in association with breathing. This constitutes vocal expression and articulation, a late acquirement as is shewn by its absence in the deaf-mute; by its enormous variation in different persons, and also by its conventional and artificial nature, it differs in every language and even dialect.

The only common language of mankind is gesture, the lalling of infancy, emotional interjections, and pictographs. These have

been worked up gradually into the conventions of speech and writing. Head thinks that by the time man developed speech, he already possessed the power of discrimination to a high degree, and definite symbols, such as words and numbers, were invented to register these differences.

The process can be traced from its beginnings in the child of normal mentality who can prattle away about things, when unable to distinguish between the numbers 2, 3, or 4 either as figures, fingers, or pips on a card. So, too, much of it can be traced back in the history of Egypt and the East.

Comparison of the most ancient fossil skulls and of intracranial casts shews that the brain areas concerned with the power of production of words were present in primitive men as they are in the higher apes. The bitemporal width, too, in even the earliest ape-man, is considerable compared with gorillas. The oldest relics of human kind shew asymmetry of brain, associated with dextrality and speech.

The area for understanding spoken words had become evident and was probably used. Still, as the parietal region was not well developed, early men had apparently little power of sustained speech, and this suggests that they were wanting in the power of memorizing a continued sequence of ideas.

Speech is made up of words, which are the symbols of thought. Judgments and thoughts are possible without speech, but they must be of an elementary nature. These judgments are based on scanty sensations of the moment and the hereditary structure of the nervous system. The child can form and express judgments before a single word is known; this is a very primitive kind of thought.

Thought consists of the arranging of trains of judgments, in accord with experience. In the brain is recorded all the life experience.

At certain regions near the surface of the brain, regions either anatomically or evolutionary convenient, like sensations, seem to be grouped together. Visual memories, for instance, are grouped in close relation to the visual projection area in the occipital cortex, and form part of the associational parietal region. A single word, however, may be a symbol which embraces experiences of centuries of thinking, and the associations of generations of thinkers. A single word may have a content which involves almost every fold of the cortex in the analysis or integration of its meaning. It is not known exactly when speech as heard, seen, uttered, or written, is built up into the words and phrases which symbolize thoughts. This is screened behind gates through which, as yet, observers have but scanty glimpses.

With all the reservations set down above, these first cortical

stations, entrances to the mazes of the brain folds, can be conveniently spoken of as cortical centres.

The integration of speech, received or expressed, lies on higher planes than these inferior cortical stations, represented by the word-hearing centre about the posterior third of the first temporal convolution, the word-vision centre in the angular gyrus, the other localities concerned with musical sound or with symbols of figures, or of form, or space, or with the motor centres concerned in word formation by mouth or hand.

Henry Head has attempted a clinical analysis of speech on the basis of its damaged results from war wounds. He describes the processes which underlie an act of speech as running through the nervous system, like a prairie fire from bush to bush, once all the inflammable material is removed from any one point the fire stops. So when a break occurs in the orderly chain, orderly speech becomes impossible.

Interference with speech symbols or thought symbols he set out in four clinical classes according to their association with the wide areas in which damage may occur to the brain.

Verbal Aphasia—the main feature of which is defect in word formation, related to damage in the inferior frontal zone of the brain.

Syntactical Aphasia—shewn by jargon speech related to damage in the upper temporal zone.

Semantic Aphasia—in which the goal of speech is lost, the patient forgetting the final meaning, associated with the functions, of the inferior parietal zone.

Nominal Aphasia—where he has lost the nominal value of words, as in damage to the pre-visual area of the cortex.

Development of Speech.—The child comes into the world, in a sense, blind and deaf. It feels and cries. In a few days the cry changes, a short, deep inspiration, and then a prolonged expiration with the cry expresses some crude emotional differences. It is the rhythm used later in speech. Inarticulate sounds begin, grunts and vowel sounds, and about the fifth or sixth week mothers think they know hunger and thirst, pain, wet or coldness by the cry. The cry and sounds, which are scarcely differentiated vowels, after a month or two pass into lalling. This is a kind of automatic exercise of the developing neurons. The child takes notice, it hears and feels, and is laughing and smiling about the third month. It expresses itself, further, by using its lips and tongue, sticking consonants on its crooning vowels, chiefly labials or tongue sounds—BA, BA, never the difficult palatal sounds—MA, MA—which come much later.

About now, early echolalia in the form of repetition of simple sounds comes automatically. In children of precocious develop-

ment it may occasionally precede their lalling. Some children remain mute for a long time, then suddenly produce much speech. This, however, is almost abnormal.

Lalling is an automatic exercise expressing an absence of discomfort ; and in a low tone, perhaps, even pleasure. Even deaf-mutes make these sounds, although I have been told of aphasic children that they did not talk to themselves as infants. Lalling may persist till quite late in mentally inferior children, and is occasionally heard in school.

At this period the child is not only learning by ear, but also visually and kinæsthetically. He watches the lips and may put out his hand to touch his mother's lips when she speaks to him. It is the golden hour for educating the deaf-mute to speak, but an opportunity almost always neglected. For want of this side of sensory education, blind children are late in speaking.

Intelligent speech begins with the understanding of some words, somewhere about the end of the first year. Word production, although done by the reflex echolalia, does not yet come in as a voluntary speech effort. The echolalic speech comes over the old emotional tracts, but voluntary speech would come through the pyramidal tracts not fully myelinated at that time. Voluntary speech varies in appearance with the mental status which at this age is equivalent to precocity. With fair intelligence, the child has begun about 18 months of age ; with only medium intelligence it will be by the second birthday, but inferior mentality may mean its delay for yet another year. Dr. Kate Fraser found that two-thirds of her mental defectives had not begun by their second birthday, and 45 per cent. not till after the third. The average age being about $3\frac{1}{2}$ years (*S.H.*, 1914. 174).

There is a period of perhaps six months during which the child uses single words. What Head calls the syntactical function has not yet developed enough to put two words in relation in a sentence.

Speech comes in waves, with apparent plateaus of arrest. At first the child is rather careless about words, gets the beginning and end of words, and scrapes along anyhow with the middle. It will substitute easy sounds for more difficult, *w* or *l* often replaces *r* in baby language. It is very fond of diminutives, which may have some psychological bearing, or may merely be an easy way of ending a word. At the same time it hesitates over words, there is a physiological stammer common. This infantile stammer may persist even to the second dentition, but usually clears up without trouble. If it persists later into school-life it is apt to be difficult to remedy.

With either normal or defective children the ability to understand words comes first. Then follows repetition of words, even

occasional phrases, mainly by unintelligent echolalia ; then, later, the ability to use them in intelligent speech.

Language is not fixed as soon as attained. Slight illness may arrest development for a time, or even throw a child back to a lower plateau passed weeks before. In rare cases, the arrest of spoken language may last for years, especially when there is mediocre intelligence. Sometimes when hearing is damaged intercurrently in other diseases, speech deteriorates. If there is any considerable degree of deafness, the younger the child, the sooner dumbness follows. If speech has not been interfered with before the age of seven it is likely then to be permanent, for although many develop the toneless deaf voice, the actual speech has become fixed in memory.

Lalling, a natural stage in the automatic action of the developing motor neurons, when the child is comfortable, may become a habit. A simple continued repetition or duplication of sounds is carried habitually into ordinary speech, mostly in children of low mentality, or those spoilt by improper training keeping them infantile.

Lisping is rare in higher schools ; not common in the ordinary classes, but frequent in the special schools. Lisping includes pupils who have difficulties with certain letters such as *c*, *l*, *r*, *s*, *sh*, *ch*, *th*, in their combinations, or who drop or slur over difficult sounds, or substitute one sound for another, putting *s* for *z*, or *d* for *g*, and so on.

The main kind of lisping, which has nothing to do with stammering, is met by teachers as substitutes of [θ], [l̥] or [ʃ] for *s* ; so that *six* would be pronounced [θikθ], [l̥ikl̥], or [ʃikʃ]. Occasionally, too, [n̥] is used as [nikn̥]. The phonetic signs here are those of *th*in, *sh*ip, and the voiceless Welsh *Ll* and voiceless *n* respectively. These defects are curable by making the child pronounce [θ] whilst the teacher places the tip of the tongue in the *s* position with a spatula or tongue guide. The [θ] is said also to occur as the result of tongue tie, although I have never noticed this. The [ʃ] may occur with very high palates. Where the teeth do not meet, either during the interregnum after loss of temporary incisors, or where the arch of one jaw does not correspond to the other, either being more sharply curved, overlapping, or leaving a vertical gap, difficulties occur with *s* sounds. Candidates for training as teachers who present the slightest lisp with dental defects of this kind should be rejected : " permanent sigmatism."

Idioglossia is an interesting condition of speech when the vowels remain but the consonants are altered, substituted, or elided. Although the child is intelligent and intends to speak English, its English is as intelligible to the ordinary person as Icelandic, which the late Professor Ker once described as " English, pure English of the ninth century." Dr. John Priestley gave a good description

of the condition in saying that infantile faults persisted *en masse* and produced idioglossia, whilst if they persisted in regard to particular sounds, it was lisping. He gives three instances of boys just over 6 years old, asked to say the rhyme of "Little Jack Horner."

E-e Jack 'Orner	Lil Jack 'Ornie	Ick 'Ak 'Orki
'A i' i torner	Sat i' a cornie	'At i' cork
E-e a Tis-i pie	E-e a Thma' pie	Eating a Kik-pa
'E put i' 'is fum	'E pu' i' 'is thum	Put i' gum
Pund ou' i pum	And pu' out a pum	A' pu' ou' a pum
A aye ot a dud boy i I.	And thaid what a good boy am I.	A' gu' wh' gam.

The cause is not obvious. Leonard Guthrie thought it due to some inherent inability to make prolonged use of the faculties of attention and observation which are necessary for the acquisition of correct speech. The writer regards it as a developmental retardation somewhere in the audito-motor arc, probably near the motor end, as the structure of the sentence is correct, and the vowels are correct, and only the difficult consonants altered. It is not a persistence of the usual baby language, nor a newly invented speech, as its name would suggest. It is probably some affection of the motor speech region retarding post-natal development after the vowel capacity has developed, but before difficult consonant sounds are attained, as it affects the whole spoken language. Fortunately, improvement is steady once it begins.

Nasality is obvious in cases of cleft palate, or where conditions of obstruction or paralysis prevent the shutting off of the nasal cavity by the raising of the soft palate. It occurs with neglected adenoids, colds, and so forth; sometimes it is purely functional. Either the open nose as in cleft palate or the shut-off nose of catarrhal changes give a nasal character to many sounds, and whilst the speech with the last type is always intelligible, it may not be so in cleft palate.

The various vowel sounds are produced by alterations in the shape of the resonating cavities. They can be imitated in Plasticine models, and by blowing across or through these Paget got the various vowels reproduced (*Proc. Roy. Soc.*, A, 102. 752). He was also able to get the consonants by interrupting the current in stop positions (A, 106. 150).

Except when nasal sounds are being used, the nose is shut off during the sounding of vowels. The details of articulation are really a specific study which cannot be gone into here. Slight changes in the form of the oral cavity, with alterations in the lips, determine the vowels. Wylie, whose book is yet one of the best surveys of speech, worked out a physiological alphabet, which is as follows for the consonants.

These stop positions are represented in the figures for oral and nasal sounds respectively (Figs. 119B, 119C). Certain of the sounds, as for instance *l* and *r*, have varieties determined by the form of the tongue in its contact with the palate, which are almost a technical study in themselves, and are beyond the range of any but the specialist. Seeing how complicated are the series of actions necessary for speech production, it is not extraordinary that variation is so great. The child picks up its speech by ear and eye, and if there is any interference with this, one or two things are to be

TABLE 83.

	Voiceless Oral.	Voiced Oral.	Nasal.	Memorial Sentences.
First stop position Labials	P W(h)	B W	M	Peter Brown made white wax
Second stop position Labio-dental	F	V		Five villages
Linguo-dental	Th [θ] S	Th [ð] Z		Thinkest thou so, Zealot ?
Anterior linguo-palatal	Sh [ʃ] T	Zh [ʒ] D L R	N	She leisurely took down nine large roses
Third stop position Posterior linguo-palatal	K H ? or Ch	G Y [j]	Ng [ŋ]	Can Gilbert bring Loch Hourn youths ?

suspected—either the child has a defect of hearing, or it is mentally subnormal. Hearing should be carefully investigated.

It is not easy to differentiate the written or spoken speech of some hard-of-hearing children from that written down phonetically as idioglossia. Sometimes there is so little voice that the child can hardly be heard. Sometimes it remains speechless, or nearly so, and one group are dumb but hearing. Aphasic children with word-deafness will be dealt with later, but the group who speak only a word or two (Hörstummheit) seem rarer in England than abroad.

Some children seem to have little initiative or desire to imitate speech. The use of pictures has been recommended to awaken interest, and lead on to speech. One condition, which is rare, is where the child has no proper speech education. Twice the writer has met hearing children of deaf parents who were much delayed

in speaking. In another case of two hearing sisters from a deaf household removed to an institution, the one aged 10 did not gain speech, but the younger, aged 7, soon learned.

A long-drawn, delayed speech is more common in Scotland

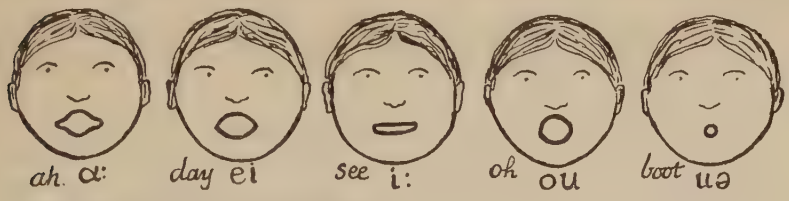


Fig. 119A.—MOUTH POSITIONS IN VARIOUS VOWEL SOUNDS.

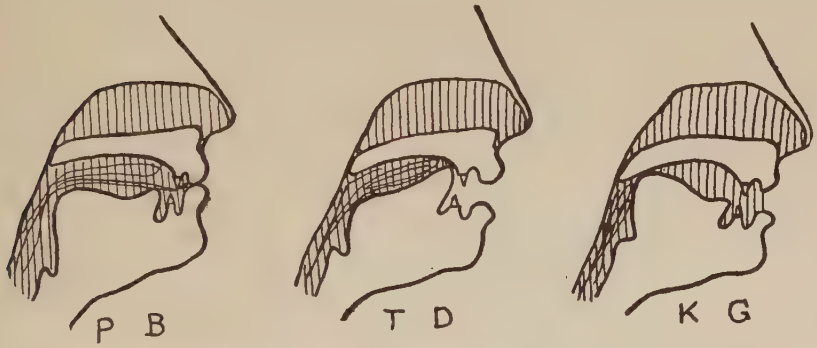


Fig. 119B.—VARIOUS STOP POSITIONS FOR CONSONANTS.

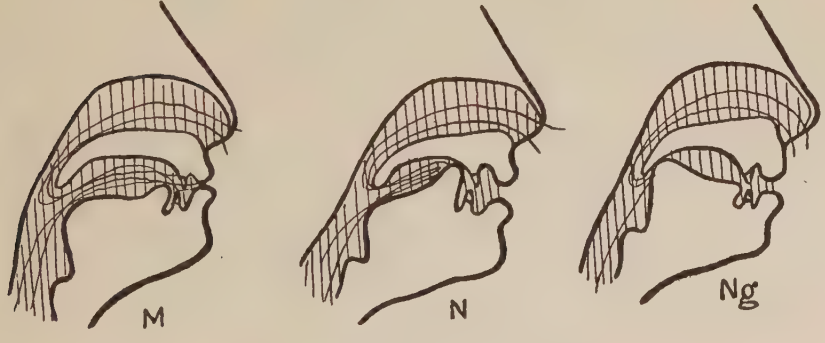


Fig. 119C.—STOP POSITIONS IN NASAL SOUNDS.

than in England, but in children it is nervous hesitation, which sometimes appears more than shyness, and is probably hysterical. Several times the writer has come across children not known to speak in school but reputed to speak at play. One girl found to be deaf was sent to a hard-of-hearing school, and some weeks later suddenly resumed speech, at first in a very low voice, which, however, regained strength rapidly.

Most cases are purely functional. Where there is aphonia, and it is commoner after puberty, good breathing has first to be secured, and re-education to be begun. The speech may return almost accidentally. It is most commonly young teachers who fail here.

Mere school nerves accounts for the child who comes with a hoarse whisper of "Please, mum," in school, but is vocal enough in the playground.

The reverse of speechlessness is occasionally encountered in a real logorrhœa. The child chatters incessantly, but is soon found to be inattentive and will probably ultimately be marked imbecile.

Some nervous children cannot get their thoughts out fast enough. Agitophasia associated with agitographia has been described by J. S. Green as an extreme rapidity of slurred or distorted speech which also may shew in writing (*N.Y. Med. Rec.*, 1916. 754). Some nervous children get their thoughts out fast enough. Some adults speak so quickly that they are difficult to follow; but these children do not give full values to words or word spacing, and a choppy, altered speech, with almost unintelligible excess of some consonants, slurred sounds, and possibly aspirates and gutturals thrown in, make up the kind of speech described as cluttering, or *poltern* in Germany, where it seems much commoner than in England. Insisting on slow speech and the presence of strangers reduces its obviousness, the reverse of what happens in stammering.

One must not expect perfect speech from a young child, there are many sounds beyond reach until several years of school-life are passed. Dr. Ernest Jones worked out the various consonants and the influence of their positions in words. *Th* beginning or ending a word, *ng* final, and intermediate *v* were the most difficult.

Articulating capacity develops earlier in girls, and they do best in sounds which can be lip-read. The replacements of consonants most common were *f*, *v*, and *n* for *th*, *th*, and *ng*. Improvement goes by plateaus, as in the earlier stages of speech acquirement, and the age 7 to 9 years and again after 10 in boys represents periods of improvement (*L.C.C. Reports*, 1907. 27, and 1908. 25).

CHAPTER XXXI

STAMMERING

Stammering.—What is stammering ? *The Oxford Dictionary* states : " To falter or stumble in one's speech, especially to make one or more involuntary repetitions of a consonant or vowel before being able to pass from it to the following sound."

Scripture, and one or two others, have applied the word to a use hitherto unknown in English, and applied it to speech defects of various kinds already described, such as lisping. This would correspond to the German word *stammeln*, but it is not the English meaning of stammering, which is *stottern* in German.

Stuttering is a redundant word which only first occurs in 1570, and possibly has a more extended colloquial use in America. It expresses a very bad stammer, where the initial consonant keeps being repeated, and there are additional overflow muscular movements. It is unnecessary for our purpose.

For *stammeln*, which has no English equivalent, Kenyon, of Chicago, has proposed dyslalling, with the adjective dyslallic. It is a useful suggestion. McLeod found among 10,000 New York children 2·94 per cent. with speech defects, of these 1·52 were stammerers and 1·12 dyslallic.

The description by Kussmaul of a spasmodic neurosis of co-ordination which obstructs the utterance of the syllables by spastic contractions at the stop positions for vowels and consonants in the articulating channel covers the speech effects.

The intermittence of stammering, its absence when the attention is otherwise directed, as in singing, or when the sufferer is alone, or, in the case of the small child, when no older person is present, shew that there is no peripheral lesion.

The machinery of respiration, voice production, and articulation are all in good working order, and do at times work well. The interference is central and psychical. Robbins, by plethysmographic observations on a trephined stammerer, shewed that shock, fear of stammering, and emotions all affected the brain volume more than usual (*Am. J. Phys.*, 1920. 168).

Stammering may be artificially produced. It is rare in Rumania, Spain, Portugal, and Italy, the lands of soft sounds, and

common in Germany and Poland. Indeed, the explosive articulatory style of the German school speech may be contributory.

Speech is slowly built up. The simplest vowels at first; the complex consonants are not fully acquired till half-way through school.

No useful purpose would be served by quoting the large numbers of statistics as to prevalence. The variation in sex age and social status is so great that anything beyond 1 per cent. of primary school children is unnecessary. From nearly 20,000 primary scholars in London the figure has been put together (*L.C.C. Report*, 1909. 50).

The almost reflex subconscious building up of speech can be interrupted easily, especially by conscious attention to difficulties

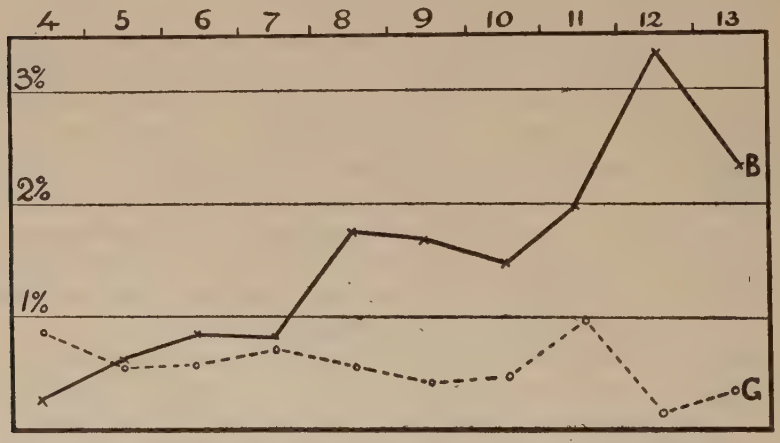


FIG. 120.—PERCENTAGES AT VARIOUS AGES WHO STAMMER (LONDON).

as in complicated consonants. Subconscious and automatic actions generally become worse done under attentive control. A mother's attempt to improve a child's articulation has been known to cause it to stammer.

Speech as an emotional product is less likely to suffer than that which is intellectually controlled. The verbalist is usually fluent and without much intellectual content. Emotional production of speech may account for the relative infrequency of stammering among girls, compared with boys.

Dr. Rose, of Aberdeen (1912), remarks on the period of stammering in early life, which, under judicious treatment, easily passes away.

This stage of physiological stammering lasts from the establishment of intelligent speech till about the second dentition. It has been suggested that the use of baby speech to children and their

own conscious efforts to correct this may tend to stammering of a physiological nature. The debility of childish illnesses often seem to be the starting-point; indeed, anything which raises the process of speech production from the automatic to the level of conscious effort is a risk in the child under 7 years of age, when speech processes are unfixed.

Cortlandt MacMahon finds that treatment is useless when the health is poor, and, according to school experience, it is the soft, pulpy, unexercised child of the better-class elementary school who is most disposed to stammering.

Rouma, of Brussels, points out that the stammerer is such in movements, thoughts, and decisions. In our London cases, a family predisposition to nervousness and irritability is noticeable. Stammering *per se* is not a hereditary character. The psychopathic nervous system easily runs out of gear. The prevalence of stammering in families is not uncommon, but is due to a general disposition to speech irregularity, in which imitation and suggestion play the greatest part.

Derhardt speaks of 79 per cent. shewing heredity, and Makuen noted 39 per cent. as having relatives who stammered. Heredity or environment fortunately here make little difference as to actual prevalence.

The predisposition existing, an actual exciting cause may be a nervous shock, fright, or injury. Causes set down were, "saw brother killed, rescue from drowning, run over, bitten by dog, operation for adenoids." Vaccination, so often assigned as the cause of squint, seems too remote to be invoked here.

Frank, of Zurich, in his pamphlet on *Anxiety Neurosis in Speech*, shews the mechanism of fear as setting up a train of symptoms. Originally an inheritance of certain reflex groupings of nervous actions built up as a protection in emergencies, it still remains, and occasionally is easily put into action by a failure to control and comfortably relegate to the subconscious, some cause of nervous upset.

After this the complex begins to accumulate further minor disturbances, till the individual gets into a condition presenting chronic mental anxiety; this, then, forms a factor in speech production. Fear is a great part of the developed symptom complex. Dr. Leary (*Med. Journ. of Austral.*, 1918, 259), who chiefly details re-education, and speaks of half a life-time devoted to getting rid of the trouble, assigns fear a secondary rôle, as the result and not the cause of stammering.

There is little doubt that the whole mental make-up of the individual stammerers belongs to the unstable nervous type, which easily develops anxiety.

This is supposed by the Freudian school to be always remotely

sexual in origin. Dr. Frank, from his enquiries, finds no trace of sexual causes, but by rehearsal of scenes in the hypnoidal condition, traced as the chief factors mental traumata in psychopathic individuals. These had occurred originally in the period of speech development, and by bringing the complexes back into consciousness, he relieved the patients of their troubles.

The majority of child stammerers recover easily without treatment. In other cases every conscious effort to control the speech mechanism, aggravates the result. The advice so commonly given : to take a long breath before speaking, to think carefully of what they are going to say, or, indeed, to direct conscious effort in any way to speech, is thoroughly bad practice.

Some methods direct the attention from actual speech production.

One medical officer of health (1912) describes how the stammerer is induced to make an action with his forefinger to enable him to speak syllabically.

The methods of stammer schools are to use queer voices, to drawl, to slur the consonants, to speak very high, or very low, or in a staccato way, syllable by syllable. Exercises, breathing articulation, or any kind of definite voice control methods, may for a time give relief, but relapse comes, and the stammering is more confirmed than before. Not more than 5 per cent. of treated cases fully recover (Scripture, *Lancet*, 1923. i. 749).

Even some of the theoretical methods, such as Swift's, derived from the idea that defective visualization of the subjects of speech was the cause, for a time got good results, but it was by side switching attention from the speech to visualization.

This functional neurosis, which is purely developmental, and has its origin in early childhood, is mostly grown out of as speech becomes organized and fixed. If anxiety becomes a part of the disposition, the irregularities are also fixed, and possibly developed, by anything straining, as for instance, calling for rapid adjustment to conditions arising unexpectedly. Kenyon has called it social emotion.

There is a large group of persons, not stammerers, who are terrified of meeting other people. Stammering helps them to avoid human society and so gives protection. This explanation may seem far-fetched, but there is no doubt about the timidity. For this reason, a stammerer can seldom learn to lip-read well.

The psychopaths who stammer are, generally, like the myope, possessed of high intellectual development.

Stammering, then, may be due to an anxiety complex which grows with time, and is aggravated by wrong methods. It may be repressed for a time, or, as in the majority of cases, it may disappear in the course of further healthy development.

" There is little doubt that the equally good results obtained by

all kinds of methods and treatments, from comparatively untrained teachers, owe their success to the common element of the teacher's complete faith in his method as the best, and its suggestive influence on the stammerer" (*L.C.C.*, 1910. 171). These varieties of treatment fail to have permanent effect in most cases, and relapses are common. For treatment, the lucky time is the ingravescent period of pre-school age. The disorder should not be allowed to persist through the nursery school years. School classes later should not be needed.

A developed stammer in a school child is a condemnation of his surroundings, and is due to ignorance or neglect on the part of parents or teachers. Much can be done for correct speech. The children of the mentally defective schools, when speech was fully looked after some years ago, were better than their contemporaries in the ordinary classes.

The methods of re-education are all very similar. There is habitual practice to eliminate the habits formed secondarily, and in accompaniment to the stammering. They depend for the result on the personality of the teacher.

The two chief exponents were Chervin, of Caen, and Berquand, whose methods have been used by several English education authorities. Chervin turned out his pupils cured in three weeks, Berquand somewhat longer. The first week, complete silence is required, meanwhile the child is made to breath freely and automatically, and then in an intoning chant, uses separate vowels ; to these are gradually added consonantal combinations. A combination of suggestion and also re-education in automatic use of the voice thus goes on and gives good results, although relapses occur.

To make this system applicable, a child must be able to read a Standard III book ; and the Manchester Report states that many of the children reported as stammerers are as yet too young for treatment. For younger children the courses are unnecessary. For adults, their use is doubtful, if not harmful in the long run, except in so far as they impart confidence.

School training for stammerers is no new thing. Potsdam first started it in 1886, and all over Germany there were classes. Holiday courses began in Zurich, and many varieties of courses and repetition classes have since been tried. Evening classes, too, have attenders. The methods used are generally rule of thumb, often ill formed and harmful.

If stammering is regarded as a fear complex, to be broken up, to remove its effects hypnotic suggestion would seem obvious. Many years ago the writer found it useful with a few children, but whether the results were permanent cure, or recurrence happened, it is difficult to be sure. In war cases, the effect was generally transient.

Frank elicited past events by questioning children in the hypnoidal dreamy condition. The younger the patient, the shorter the analysis needed, but in some cases their environment has to be changed. It is necessary, if possible, to catch children in the pre-school age, as school strain aggravates besides helping to confirm the stammering. Frank and Crichton Miller seem to have had good results from repeated hypnosis and suggestion. Prognosis of any treatment is unsatisfactory if inferior mentality comes in. Gutzman found 3 per cent. wrote mirrorwise with their left hands, and on that gave poor prognosis. The other condition is poor health. A robust, well-nourished child will do well; a debilitated one will not improve.

Of recent writers E. Tompkins, of Pasadena, gives the most scientific account of the process, and contrary to tradition criticizes exercises unmercifully, objects to seeking complexes, or cultivating visualization, points out that hypnotism is but temporary in effect, and advocates a policy based on Liebmann's teaching.

Liebmann insisted that attention to speech was a mistake for stammerers, and as it were sensitized them. Tompkins regards stammering as a panicky interference with speech. The interference is not involuntary, but the fright is. He instances a mechanism in a normal child who has just acquired speech. A vehicle knocks him down. His mother picks him up, and questioning begins, "Are you hurt?" Endeavouring to speak when its automatic speech is knocked out, the child is almost sure to stammer. The proper procedure, then, is to prevent it. Speech should be prohibited, especially at its inception. As it is intermittent—a fact which shews that the stammerer can talk—the prohibition of defective speech only allows normal speaking, and this normal speech gradually removes the fear which prompts the stammer. When fear is gone, the impediment is conquered.

Rational treatment, then, is restraint of stammering (wherein the Berquand and Chervin methods have their chief merit), and then the cultivation of spontaneous speech. The stammering classes of the education authorities should be abolished and treatment be undertaken in the pre-school and infant ages.

CHAPTER XXXII

CONGENITAL APHASIA

It is not yet possible to write an account of the origins and development of the faculty of speech.

Far back in the animal series the reactions of emotions became, in some measure, stereotyped by gestures, the hereditary remains of older reactions thus persisting.

Gestures in the higher animals were accompanied by respiratory sounds. With the development of the associational complexity of the neopallium, the sensations of sounds heard were remembered and associated with mental conditions, of which they became the symbols. This was developed as articulation of definite groups or sounds. From these were drawn pictographs, which became shortened in writings, and ultimately progressed in some cases to alphabetic symbols of sounds wherewith words were built.

The spoken language has always gone ahead of written speech. It is more emotional and less intellectual, and the two forms differ materially in detail. Sounds themselves have altered. My own name is spelt in one form, and by certain sections of the population pronounced in another way. The town of Banff has its name spelt with an *n*, but for ease of pronunciation is called Bamf, and so on. In the English language the number of sounds is nearly double the number of letters which nominally represent them. Some of our letters stand for sounds dead for centuries.

We need shorter and more fluid graphic symbols for all purposes. Our written speech hampers us mentally, although not in such degree as their ideographs hamper the Chinese.

Speech is the whole process of transfer of ideas between individuals. Its graphic forms are not bounded by time or place. By its aid we have received some life experiences reaching back to those who vanished tens of thousands of years ago. We exchange ideas with our contemporaries and we can transmit our knowledge for the benefit of others for ages after we have ceased to be.

A word is a symbol of a very complicated kind. Its whole meaning may vary with its position in a sentence. The sentence itself may have half a dozen different meanings according to the rhythm, stresses, or tone of voice with which it is uttered. We

think in sentences, not words. A single word may in different ways form a dozen sentences.

The old localization of cortical centres, like the old faculty psychology, has broken down. If " centre " is taken as a symbol for sphere or region in a functional sense, it may still be advantageously employed in a diagrammatic way.

This will serve, with rare exceptions, all the cases of aphasia seen in school.

The classical scheme of aphasia will therefore be retained for convenience, knowing that while it symbolizes the processes in most cases, it will on occasions fail. The other schemes do not give so satisfactory or easily acquired working expression of the chain of

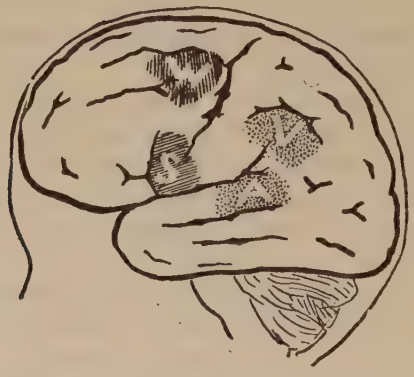


FIG. 121.—THE LOCATION OF CHIEF SPEECH CENTRES ON LEFT HEMISPHERE OF BRAIN. THEY REALLY ALL MERGE INTO EACH OTHER.

A, auditory; V, visual; W, writing; S, speaking.

events, and have no advantages for our purpose. For some cases they also fail.

The riddle of aphasia has not yet been solved. The usual representations of the chief centres on the left cortical surface is given above.

The aphasia defects have not had the attention that their importance warrants. Each case should be thoroughly examined, as a knowledge of the condition is important educationally. One should, if possible, determine which functions are normal, which are suffering interference, and what compensations exist.

A case like the following could hardly happen now. A doctor called to testify as to the fitness of a child for special education tested him with reading, and gave evidence that the boy could not spell a three-letter word. The father demurred, and spelling out certain words asked the boy what they were. He answered readily, and again when asked to spell certain words mentioned, did so

correctly. The magistrate now took a hand, and tested the child, with the result that he agreed with the father. The doctor could not believe his senses. It was only when he later narrated the case and was told about congenital aphasia that the apparent discrepancy between his report and the boy's performance, the one visual, the other auditory in function, was clear.

Forms of the so-called transcortical aphasia seen in disease, are unknown as congenital cases. Our records only shew forms which must be considered cortical. There are cases where the symbol defect is extraordinarily limited, and there are many varieties of such specific variations to which I applied the term congenital aphasias (*Lancet*, 1900. i. 1446) as typifying a class of defects.

The lowest level functions concerned in speech may be grouped—

Sensory.	Motor.
Spoken words (Auditory).	Spoken words (Broca's aphasia).
Written words (Visual).	Written words (Agraphia).
Kinæsthetic and Tactile (Motor).	Kinæsthetic (Mimicry).

The tactile source of ideas appears of value in the first year of life. It is one of the main avenues for the blind, and was the door through which Laura Bridgeman and Helen Keller gained their education.

In school children the commonest form seen is, where visual sensation of words is not properly apperceived, a congenital word-blindness. This may be said to exist in every individual born, so that the terms "developmental alexia" or "dyslexia" suggested by an American writer are more correct, and, involving no theories, fit the variety and course of the cases.

Children presenting these symptoms had been known for years, as recorded by Nettleship and others, although not separately described (*Ophth. Rev.*, 1901. 61).

The first actual reference to the clinical groups of various aphasic defects is my own in the Howard Essay submitted in 1896. "Almost unique cases are found with most bizarre defects. Agraphia, for instance, may be unintelligible to a teacher, especially if it occurs—as in one of my cases—in a boy who can do arithmetic well so long as it involves Arabic numerals only, but writes gibberish in a neat hand for a dictation exercise; a boy with word-blindness who can spell the separate letters, is a trouble; another, who has only since his ninth birthday begun to speak intelligently, although understanding all that is said; another, who not imbecile, hears well and is dumb. These are extreme cases, but slight cases are also met."

Congenital word-blindness as a separate entity was described by Pringle Morgan in the same year (*B.M.J.*, 1896. ii. 1378), and now there is a large literature. The late Dr. Hinshelwood wrote the best account in his book on *Word-blindness*, and from this time on it was a common observation in school-work.

The contrast with a case of word-blindness in ophthalmic practice—a man who had hemianopsia and word-blindness, but could write letters and make out cheques, although he could not read them—lead to a demonstration of the various types of congenital aphasia at the Bradford Medical Society (*Lancet*, 1900. i. 1446).

An aphasic child with hemianopsia would not belong to the congenital group. "That which dominates all is the difficulty of learning to read," says Variot in the first French paper on *typholexie congénitale* (*Gaz. de Hopitaux*, 1906. 1479).

Simple signs, ideographs, the Arabic numerals, and single letters, the individual's own name, and the use of capitals for proper names, are generally learned easily and used intelligently; sometimes even in these there are difficulties. Many persons lose all facility and even forget reading a year or two after leaving school.

The writer, in his hospital practice, met patients who stated that they could read at school, but now half a dozen years later had difficulty in naming some of the block letters on Snellen's test types.

A word-blind boy who did long division well was unable to manage more than simple integers when examined four years later.

The condition, therefore, is very variable in degree, alphabetic, syllabic, or word-blindness. The power of retaining symbols is also easily lost in many cases. It was the gibberish writing which led to my first detecting these cases in 1893.

Dr. C. J. Thomas about 1904 went over many London cases. He estimated 1 in 2000 boys as affected (*Ophthalmoscope*, 1905. 380). Warburg in Cologne, in one of the best papers on the subject (*Zeit. f. Kinderforschung*, 1911. 97), found 14 word-blind among 2000 normal school children and 7 in 400 special scholars. There were 12 boys and 9 girls.

J. E. Wallis Wallin found 4·48 per cent. among 2116 St. Louis cases referred as feeble-minded, in the proportions of 4 boys to 1 girl (*Training School Bulletin*, 1920).

Cases with loss of words, but recognizing letters, or single symbols, were the first noticed. It was then supposed that these letters were retained by kinæsthetic memory, but cases are known where they are lost.

It seems commonest to have a defect higher than the visual representation, the power of letter combination being wanting.

A good illustrative case is the son of an English colonel, who had

had three tutors unsuccessfully attempt to teach him to read, before his dissatisfaction caused him to run away from home. He began at the bottom of the ladder in an engineering shop, and rapidly rose through all stages to be a consulting authority. He has been able to do all necessary calculations, using logarithms and mathematical tables, and working out most complicated drawings of marine engines, but needs the aid of another hand to letter the drawings, as he is completely letter-blind and " unable to read even the name of a street."

The case reported by Pringle Morgan was a boy who, after seven years at school, could only spell one-syllable words, but readily worked out $(a + x)\ (a - x) = a^2 - x^2$, given him in algebraic symbols.

One little gipsy girl who was quite letter-blind at once picked out the Greek delta (Δ) and said, " that means they have a dog there." There are many varieties. Some children merely confuse or mix up a few of the letters ; others fail to recognize more than one or two. Some cannot read. Some read a little with much difficulty, spelling over the words to themselves. Alexia and dyslexia and symbol amblyopia have been used to express these conditions.

Some cases have also difficulties with numbers. One of Fisher's cases (*O.R.*, 1905. 315) could not learn the pianoforte as she could not manage reading the two sets of notes for bass and treble, but she was able to learn the violin.

The slighter the degree of defect, the commoner it is, though frequency would probably arrange itself in the ordinary curve of error if worked out. There are all grades of defect, and it is only in very marked cases that other channels or routes are not used to fill up, obliterate, or mask the sensorial gaps.

Congenital Word-deafness is a part of the group of congenital aphasias. The first case thus described was one of my own. Years later, as is usual, past descriptions were found where such cases had evidently been seen. Ireland, in his work on mentally defective children (p. 325), says: " There is a small class who may be styled idiotic aphasics who remain obstinately mute, though it is clear they have more intelligence than other children who talk volubly. Sometimes, indeed, they have so much intelligence that people doubt whether they are imbecile at all."

R. Coen (*Z. f. S.*, 1889. 412) described as *Hörstummheit* children, mostly boys, with a congenital form of inability to speak, characterized by normal bodily and mental conditions, and speech organs so normal that the separate sounds could be used, but not words.

These are descriptions of congenital word-deafness—

In 1894, the first case fully observed was being looked for as the result of having two cases of congenital word-blindness, under

notice, and yet he was under observation for two years before the condition was realized. As a child of 4 years, the boy seemed alert and could hear well, but did not understand and never spoke. Between 6 and 7 he was transferred to the deaf school to try the effect of articulation lessons. After some months he was removed at the teacher's request as imbecile. As he still seemed alert he was put into a special class for careful observation. He was found not to answer to his name and yet he undoubtedly heard, and could name the other children.

On the possibility of word-deafness, attempts were made to teach him the sounds by writing and articulation. He soon gained the words " pen " and " penny " and " pan " and " pin," and a vocabulary was slowly built up. He learned writing quickly, and picked up speech by kinæsthetic memory. If a question were asked him, he would repeat it noiselessly with his lips, before he could understand it. He made good progress and learned to speak and sing, with expressionless tones like a phonograph. He could draw well.

But for accident, this boy might have joined the " idiotic aphasias " of Dr. Ireland.

He gradually acquired the power of putting together sentences, when each word was said separately, but it was three years before he appeared to realize speech from spoken sounds. He was 13 years old before the slovenliness of his articulation improved, and before speech heard began to be used. Even at 15 he still had difficulties in understanding many words, and although his hearing was good he did not apperceive many special sounds, such as the sounds of various unseen tools.

Wernicke thought that cases of word-deafness could not read, but this boy wrote well and read, so that the visual route was clear. It was very noticeable how much in his earlier years he trusted to automatic lip movements, repeating everything noiselessly.

Some cases are deaf solely for words and sentences, some like the boy above, for many other sounds. On the other hand some are musical, and may be able to imitate animals like Syme's case (*B.M.J.*, 1904. ii. 1229). Dr. Eva McCall's case used lip-reading (*B.M.J.*, 1911. 1105). Thomas describes one to whom a picture of a house was shewn. Which is the roof ? No answer. Now the roof pointed to, and the child at once says " the roof."

These cases are rarer than cases of visual aphasia, as one would expect. They are common enough for most school doctors to encounter at some time, but may easily be missed.

The classical explanation of aphasic symptoms involved an ideational, intellectual, or apperception centre. Although some writers have tried to exclude this as unnecessary, there is no doubt that there is a highest speech region for human speech

as distinct from animal sounds. We may picture it as an epicritic function.

The infant and the animal, as well as the human being on an animal level of intellect, have reflex or emotional sounds of ancient origin, and more persistent and unchanging than the comparatively late evolved speech. The nervous traces resulting in these sounds follow other paths than the pyramidal tracts which are recent routes chiefly for voluntary intellectual performances.

The old road, on which the lenticular and rubrate nucleus are stations, may account for much speech that is almost reflex.

" Yes " and " No " and more emotional expressions may follow other tracts than that of voluntary functioning. They are not

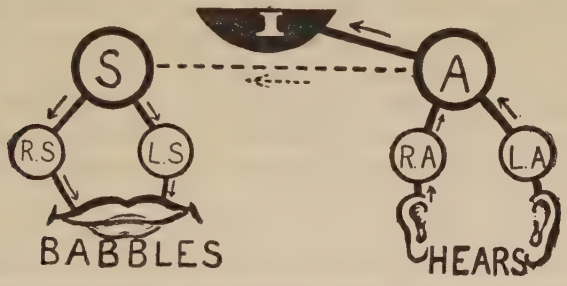


FIG. 122.—CONNECTIONS IN A BABBLING INFANT LESS THAN ONE YEAR OLD.

Dotted line indicates the connection developed when echolalia appears. RA and LA, the lower auditory centres; A, auditory centre; S, Broca's motor speech centre; RS and LS, lower speech centres; I indicates the higher centres of association.

voluntary expressions in aphasics. The delegation of function to lower levels and through other routes has yet to be worked out.

Echolalia will follow the old motor route of animal sounds. It exists before the newer highway for conscious intelligent speech has been opened, and may shew up when this is obstructed.

Emotional and reflex movements can persist when voluntary are absent. Hughlings Jackson noted that the aphasic who could not put out his tongue when asked, licked his lips afterwards. The converse may happen. A small boy patient of my own had the muscles supplied to the right side of his face completely unresponsive to all reflex and emotional stimuli. He was in no other way abnormal. He performed every action equally and symmetrically when asked, but to a joke or a pin-prick, the right half of the face remained immobile, whilst the other half was distorted.

Nothnagel drew attention to these cases in connection with the optic thalamus, and they were described by Exner before the Austrian Society for School Hygiene in 1912 as shewing the separation of the two motor routes.

Similar conditions of separate routes appear in echolalia where a stimulus provokes a response of echoed sounds, when a voluntary response is unobtainable. The possibility of much speech being the action of lower centres without material conscious intellectual content is obvious, not only in echolalia, but in the " bromides " of everyday life. The tendency of life is to make conscious efforts into automatic habits.

This fixation into automatic and subconscious action is by delegation of the highest associations to lower centres, and almost subconscious action, by which indeed the action is often better performed than when attention is given to it.

There is a distinct deterioration in performance when one is conscious of being under careful observation, and through higher centres performs actions which are commonly left to lower. This fixation of habit is at once a purpose to be achieved by education and a pitfall to be avoided.

There may be a functional suppression of the highest capacities of speech or ideas expressed, without very obvious symptoms in the speech itself, apart from the general conduct of which it is an expression.

Sometimes little points suggest the activity of these higher centres. Dr. Thomas relates how he taught a boy who was somewhat deaf to say, " The road is almost like a *stream*," and a quarter of an hour later, being asked to repeat this, he said, " The road is almost like a *river*." This was taken at the time to mean retention of a visual rather than an auditory image. In testing rapid reading of unseen print by children there is often substitution of a word of somewhat similar meaning for a word only seen a fraction of a second before. Occasionally " King " replaces " Monarch," " tonsils " is read for " tongues," " up " for " down," " stick " for " staff," and so on, shewing that there is in action a higher level than the mere visual image. Even in copying, printed letters are sometimes reproduced in script by a child who is agraphic for words.

Much of this will be elucidated later in the greatest of all educational laboratories, the scientifically observed nursery school where the developmental mistakes of normal children will be followed. Such substitutions do not occur in echolalia, but where other channels are being used substitutions and variations come in through the action of higher levels. Inaccuracy in echolalia is an indication of higher level action than accuracy, which is the mechanical reflex of the lowest level.

A child with some interference in or above the auditory sphere, so that there was a failure in auditory word memories, used lip-reading a good deal, and was echolalic. Here the echolalia was maintained as a habit by which the obstruction or break in the

auditory sensory chain was got round, through the kinæsthetic perceptions from the lips and tongue. She gradually learned, first the echolalic repetition of the question, and then in answering had the pronouns altered. *Ques.*—When is *your* birthday? *Ans.*—When is *my* birthday? Then the voice was suppressed, although the muscular movements remained, and the only audible reply was "December 30th."

In the course of years many of these children attain perception through various channels, so that they are judged as not hearing as quickly as they ought.

Before leaving the sensory side of speech affections mention should be made of several other apparently specific failures, the most common is amusia, where the sense of musical notes, or the appreciation of music, is wanting. All variations in this faculty exist from the tone deaf to the child of 8, who could accurately name any isolated note struck on the piano from across the large hall of the school, a sense of absolute pitch which the superintendent told me was rare.

But poor appreciation of pitch and rhythm are fairly common, and whilst imitative music as an emotional expression is a valuable outlet for primary school children, the teaching of musical theory is a criminal waste when it excludes sufficient time being devoted to more practical subjects as healthy living and development of physique.

Henschen, who has studied amusia, and acalculi, attempts to determine a centre for music, but thinks that calculations involve such complex functions that any idea of location is impossible. It will be remembered (p. 373) that there are two quite different types of calculators, audiles and visuals, so that the function is certainly not low level, although specific, and of little value as regards general intelligence.

The sense of space, stereognosis, is also sometimes wanting in people who, for instance, cannot draw, and a quite intelligent pupil has failed over the Binet diamond. Kaeppfli (*Z.*, 1890. 220) directed attention to pupils who seemed to have no idea of form, and called it form-blindness. Bappert (*Z. psych.*, Bd. 21. 4–6) pointed out that in the Binet tests the lower half of the rhombus gave trouble, and that backwardness in reading was closely related to this defect. The condition, like echolalia, is found almost as a regular stage of development in the nursery school.

If small children are set to draw what they see, not asked to draw what they know, many varieties of reversals and doublings appear, some of which are optical, some psychical. This requires a skilful analysis in the nursery school.

So far we have traced interference with speech by failure in the lowest nervous mechanisms of auditory and visual representation.

These two spheres at this level are quite separated by the clinical findings. The musical sense, too, is separate from the appreciation of word symbols or numbers.

Also visual appreciation of letters, words, figures or ideograms, and even form sense may all be separated on clinical findings. A further separation is found in responses such as echolalia, which distinguishes speech merely repeated, repeated with very slight modification, repeated with considerable modification, and also modifications without repetition, yet in mechanical and unintelligent platitudinous response.

The organs of speech production are also used as sensory apperceptive apparatus, apparently through what may be called the echolalic channel. In certain cases where higher auditory passages are blocked there may either be audible repetition or silent repetition before words are understood.

The correct way of teaching the youngest children is by the word spoken and heard. The written and printed word has to await school-days.

These kinæsthetic movements of speech not only substitute, but may reinforce weak auditory sensations, and so, too, visual sensations are reinforced, not only in the deaf child who watches the speaker, but in the normal baby who wants to take hold of his mother's mouth, and in the "flapper," whose lips move as she peruses a novelette in the "Tube." It is probable that the memories, although unnoticed, are part of the regular physiological process of normal speech apperception. They are much older than the visual appreciation of graphic signs, and may be more important than is suspected. Beside them the hand movements of writing, although used in every infant school, are of scanty value. Possibly the memories of ocular movements may also play a part, at first in the actual movements and their range, hence the value of large objects and letters in the infant school. Later, it is only as revised memories that they will come in.

Before passing from the sensory to the motor side of the speech mechanism, there are the higher regions or levels of association about whose action little is known. Some of the mute but intelligent children may come in here. It is also the region of the functional suppressions of fright and hysteria.

Quite a clever little boy, who is highly intelligent, draws well, can read and understand and pronounce or spell any word, cannot form a sentence. He was in a hard-of-hearing class as the hearing seemed a little obtuse, but his defect was almost certainly an aphasic condition. Asked to say "my boots are on my feet," he says and spells each word correctly, and then asked to repeat it, says "my boots is my foot." Then some perseveration shews, for asked to say "my hat on my head," he says "hat my foot."

Some of the children are classified as imbecile, though, if their defect could be traced out, intelligent speech might be attained and their powers developed. Most of them apparently have defect in the higher levels, of quite a trivial nature, although its effects are so disastrous. In the majority, but not all, there are other grievous nervous failures, and they remain imbecile.

On the motor side of aphasia the congenital cases if any exist, will be found in asylums. Here one is on very debatable ground, for the classical description on which the theory of aphasia was built, has been contested by Marie who asserts that all aphasia is sensory, and that any lesion of Broca's convolution gives rise to apraxia, and that what is called motor aphasia is aphasia + apraxia. Head spreads out the field farther, and refuses to acknowledge in the usual sense any localization.

Sufficient facts do not exist at present on which to base a theory free from objection. There are facts which no theory explains, and the idea that aphasia is a shock symptom is of no use to explain congenital cases.

Motor aphasia, if it exists in children, appears to take the form of dumbness. There is no gibberish utterance of intelligent children, and one never sees a case which could be called pure congenital motor aphasia. The nearest evolutionary or developmental condition is idioglossia. Children who have it develop with functioning and improve by schooling.

There are intelligent mutes who are not deaf, and do not suffer from word-deafness. They are generally of a nervous disposition, and may have uttered only one or two words. They are analogous to shell-shock cases, and under stress may suddenly talk.

Experience is against congenital motor aphasia existing in the way that the visual or auditory varieties are evident. This would agree with Marie's theory of aphasia. On the other hand, one has been told of dumb children, that they never babbled as infants, which, if confirmed, would go to establish an absent motor speech centre.

The writing agraphia which is found takes the form of attempts with misformed letters, which never occurs with intelligent children, or whilst the letters are well formed, they are jumbled together so that the forms of words are all wrong. Capital letters, strange to say, are generally used where capitals should be, but the letter is changed. The third specimen on Fig. 114 illustrates this.

A case of word-blindness writing from dictation in which the word "Druids" occurred, rendered it "Haeres." They use words freely but cannot write one, two, three, correctly, although figures may, as already said, be correctly used in algebra, logarithms, and so on.

It is quite impossible to say that any restricted cortical region

is connected with definite speech functions. Whole areas have been removed with the intention of abrogating speech, but without effect. On the other hand, lesions corresponding to those expected are found in the great majority of cases. The most interesting are in connection with agraphia. Congenital agraphia is a disturbance somewhere higher than the motor level.

It is generally taken as dependent secondarily on lesion of Wernicke's sensory area about the angular gyrus, but cases of nearly pure agraphia have been operated on to find nothing wrong here.

The second frontal convolution, where writing images are supposed to be stored, has been destroyed or removed without affecting writing. In a pure case of agraphia for words, but not for letters, Van Gehuchten reported the blocking of a small vessel supplying this area. In another, who, however, could copy perfectly, after five years of trouble, McConnell removed a tumour pressing on this area, and the agraphia disappeared in three weeks. Similar experiences have been met regarding Broca's convolution. These pathological conundrums probably mean that there are many routes between different brain areas, all involved in the final product of intelligent speech.

The original idea that defective cerebral machinery is the origin of congenital cases, and that biological variation might be expected to occur symmetrically affecting both sides, is borne out by the conditions being commonly familiar.

Speech variations of different kinds are common, the mother often volunteering that she or some of her close relations had been similarly affected.

S. Stephenson (*Ophthalmoscope*, 1907. 482) recorded six cases of congenital family word-blindness in three generations.

Dr. E. Plate, in Hamburg, published four cases of the same in one family (*M.M.W.*, 1909. ii. 1793). Hinshelwood reported six cases in two generations of a family.

There is a paper on Hereditary Aphasia by Stone and Douglas (*Brain*, 1902. 293), but it deals with syphilitic subjects and is apart from the question of congenital aphasia as a hereditary condition.

Observation of heredity leads to the deduction that there was little use in trying to train non-existent structures, and that other educational means were necessary. This conclusion was based on a few extreme and hopeless cases. But these children are still plastic, and great powers of compensation exist. The auditory aphasics do very well in time, and the slighter cases of visual aphasia may end up as merely bad spellers or poor readers. Hinshelwood took a very optimistic view of the pure cases of congenital word-blindness which is not found justified from primary school results, or, for instance, the case of the consulting engineer (p. 615).

One boy, bright and intelligent and of great ability in many ways, was determined to read. It took nearly two years to learn to write his name, and all efforts to read were, after three and a half years, of no avail. Recently it has been found that many even of the worst word-blind can learn to read Braille easily.

These cases need very careful analysis. They look simpler on paper or in the final diagnosis than they are in reality. Many of the records have statements incompatible with the diagnosis reached. The children are often highly intelligent, and if justice is to be done to their other capacities, the whole circumstances require working out by weeks or months in a children's institute or psychological observation school, such as that suggested in London Reports about 1906–7.

The knowledge to be obtained by careful study is widely applicable for normal children, and of importance in general education as well as general medicine.

The group of moral imbeciles as a specific variation is exactly similar to these aphasics, and has been referred to on page 413.

CHAPTER XXXIII

DEXTRALITY AND LEFT-HANDEDNESS

The left side of the brain seems to be the one which functionally is most highly evolved. The hand chiefly used is largely a matter of habit and convenience. Men button their clothes in one direction, women in the opposite. The man architect who designs a kitchen may reverse arrangements, such as the draining board of the sink on the right, when every woman wants it on the left. Some women are miserable in a left-handed house. Right-handedness is also of old descent. The palæolithic man figured in the caves of La Madelaine holds his stick in his right hand, and a prehistoric aurochs' horn scratched with a hunting scene has the stalking hunter with a javelin in his right. Elliot Smith has demonstrated from the lunate sulcus that the oldest Londoner and also Pithecanthropus were left-handed.

The one-sided specialized aptitude or capacity associated with the psychical phenomena of speech so marked in the left brain is best described as dextrality. Dextrality is a separate quality from left-handedness. Pure left-handedness appears a Mendelian recessive, and possibly in some families sex linked. Ramaley estimated the character as possibly carried by one-sixth of the population (*American Naturalist*, 1913. 730).

It is only in a small number of persons that the right brain seems to have taken the part normally filled by the left in respect to speech. In consequence, with these people the nearest motor centres, those for the left hand, seem most used, and the right remains accessory.

In cases of transposition of viscera, where there is any note of this function, it is generally right-handedness. Péré (Toulouse, 1900) notes 23 right to 5 left. Five children found in school with the condition were all right-handed.

Associated frequently with left-handedness is a reversal in the psychical sphere which may shew itself in many ways, and habits and customs of wearing clothing, tying knots, drawing diagrams, parting the hair, and so forth, tend to present a negative image of what is common. The bodily asymmetry in specialization is not only concerned with the hands but affects foot, eye, and other

parts. Lombroso thought left-sidedness very much more frequent than left-handedness (*N. Amer. Rev.*, 1903. 440).

In the case of vision, other things, such as refraction and so on, being equal, the right eye appears superior in visual memories and fixation. This shows crudely in medical inspection, when right eyes are generally reported best.

Franklin Jones, of Dakota University, measured 20,000 persons, and concludes that handedness is congenital. The born hander is shewn by larger measurement of the bones on the major side, but the transferred hander, that is, acquired handedness, is shewn by increased muscle swell on the side of transfer. He concludes that 96 per cent. are born right-handed and 4 per cent. left-handed. Of the born lefts 77 per cent. are transferred to the right hand. Elliot Smith and Wood Jones had previously determined this asymmetry of bones.

A few exceptional records exist of " crossed aphasia " where a right-handed person has had extensive damage to the left brain without any aphasic symptoms, or, where in a right-handed person left-handed paralysis with right-sided brain disease (emboli) has occurred with aphasia. Some, but not all of these people, have been left-handers by heredity, and apparently right-handers by training, but there are cases where this can be excluded.

Dextrality, then, is a psychical function usually shewn by the left side of the brain ; in rare cases it is associated with the right brain, when the individual exhibits pure left-handedness with other reversed actions. This function when present in high degree will give a left hand almost as capable of specialized refinement as the right. Famous masters of expression, great artists, famous ophthalmic surgeons, can generally make more use of their left hand than other people. They are truly ambidextrous.

There are also those who have no well-developed dextrality, whose fingers are all thumbs, who are ambisinistrals. One does not think of them as fluent speakers.

From the developmental standpoint there will be three classes of dexterity—

1. Highest development of both hands—ambidexterity.
2. Ordinary condition, one hand well developed, the other accessory.
3. Defective functioning of both hands—" ambisinistrality."

With the comparatively few in the first class is associated high intellectual expression, with a low proportion shewing any kind of defects.

In the enormous majority who make up the second class, right- or left-handedness is an accident not expected to affect mentality, and other defects are present at the normal rate. Mentality may

be affected, and shew in over-compensated subconscious inferiority making them assertive and difficult later in life.

In the last small class of individuals whose dextrality is not properly developed, and who in this sense, and often in other ways too, are mentally defective, examination may be expected to shew not merely *gaucherie*, but speech defects, squints, and various degenerative stigmata.

Training and practice and imitation of others will lead to further subdivisions in the capacity of the hands. Poor dextrality may be improved, and many left-handed trained to do right-handed work and only appear partially left-handed. Training a left-handed child to write a normal script is quite a different series of actions, to those done by the ordinary writer, so that education may have a greater strain for some.

The proportions of ambidexters and left-handers, and also mirror writers with the left hand, was shewn by Gordon to be greater among the special schools for mentally defective (*Brain*, xliii). They would probably all be included in our third group.

If we devised a set of tests to measure dextrality, such as rapidity of tapping, accuracy of adjustment, strength of grip, or other comparative tests, the results could be set out in a diagram.

In the figure, the central line represents the average value of dextrality, and the groups are marked from this in increasing values towards the right, and in diminishing values towards the left. This gives a curve approaching the normal curve of error. If among them a separate curve was made only of those who got the best result with the left hand, then a similar curve to the first, but much lower, would represent mainly the pure left-handers.

They will be distributed proportionately throughout, but many of the so-called left-handed, the class who have given *gaucherie* its name, are of low dextrality, of our third class above, and will all be included in the dotted part of the figure.

Left-handedness is found in about 4 per cent., depending on the details of the testing and the classes tested. For instance, Stier found 3·9 per cent. in about a quarter of a million German soldiers, varying from 2·3 to 6·5 per cent. in different categories. The one-year volunteer of high social status and superior education shewed least (*Neurol Centralblatt*, 1909. 613).

Of 1000 prisoners at Sing Sing, 5 per cent. were left-handed and 2 per cent. ambidextrous. Gordon found 18 per cent. mentally defective shewed some left-handedness.

The infant until the stage of the beginning of speech development towards the end of the first year, grabs with both hands and gives little evidence of dextrality. Baldwin's child used both till it became right-handed at 8 months, before she could creep or walk or utter any articulate sounds.

During the latter part of the first year it only develops slowly, so that even the toddler has to be corrected as to social conventions in shaking hands, or using its porridge spoon, or knife or fork. Many children commence to play games left-handed, and this is almost a fashionable pose.

The general test is the use of the right in special acts. Using scissors, polishing shoes, cutting bread, spinning coins, dealing cards, are examples not interfered with by education.

Hugh Gordon had a pair of scissors with a rather loose joint;

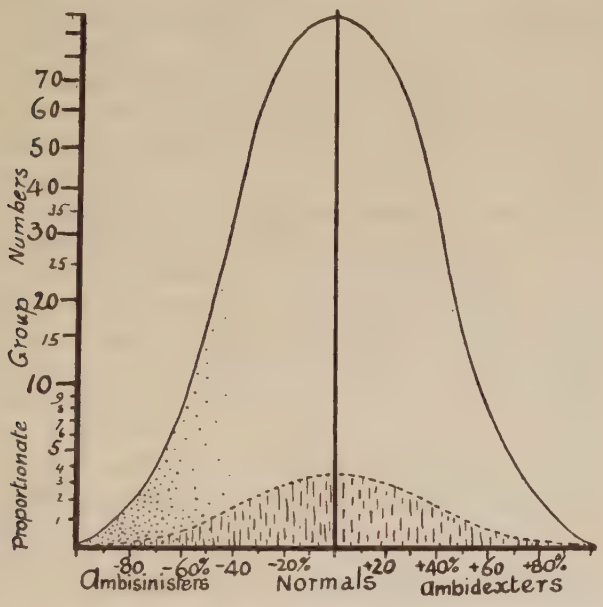


FIG. 123.—DIAGRAMMATIC REPRESENTATION OF DEXTRALITY IN POPULATION (LOGGRID).

used in the left hand a right-hander could not cut with them, but a left-hander found no difficulty.

Rosenbach's trial of the eye used mainly in fixation, and relative visual suppression in the other eye is a rough test of dextrality (*Munch. M. Woch.*, 1903, No. 36. 43). It is described on page 480.

B. S. Parson has recently put forward the theory that it is the predominant, fixing eye which determines superiority of the cortical area corresponding, and that dextrality follows.

The test in Rosenbach's form is very rough. The writer is ambidextrous, with a family history of left-handedness, but is right eyed. Ballard found less than half the pure sinisters and dextro sinisters left eyed. Enslin (*M.M.W.*, 1910, No. 43) found right-handers always right eyed, left-handers one-third left eyed.

Rapidity of tapping, accuracy of adjustment, and strength of grip have been used by Beeley to shew sinistrality (*Chicago Ed. Monog.*, 1918, No. 8).

Wherever in absence of peripheral cause there is found more efficient action on the left side the individual may be taken as left-handed, but where there is no great difference, and both are below the average, it may be looked on as poorly developed dextrality.

Van Biervliet, writing on sensorial asymmetry, states : " Les ambidextres sont en réalité des gauchers pour la sensibilité." He finds about 2 per cent. true left-handers, 26 to 28 per cent. ambidextrous, and 70 to 72 per cent. right-handers (*La Rev. Psych.*, 1908. 49).

The knowledge of right and left comes later than the development of dextrality. Binet and Simon ask : " Shew me your left ear ? " At 4, none point to the left ear ; at 5, half ; and at 6, all normal children.

Mirrored Actions and Mirror Writing.—In many people abnormal action in the psychical sphere results in some actions being mirrored—that is, lateral inversion of what was intended happens. Although often associated with left-handedness, it seems independent. It also occurs with brain disease, and the first recorded medical case was an hysterical girl in 1688 ; *læva manu, ordine inverso, a dextra versus sinistram, Judæorum more . . . quæ scripsisset, legi non possunt, nisi obversa speculo.*

The commonest form is mirror writing, where the child writes freely but whilst the writing retains its peculiarities there is specular inversion. It appears as correct writing would, if reflected in a mirror. It occurs in partial form in the developing child, some letters being mirrored. Its name, the first set of symbols learned, is for a time by many spontaneously written in reverse.

These nursery reversals point to lateral orientation being developed *pari passu* with dextrality. A stage occurs at which children only mirror signs which they already hold in memory, others being copied correctly.

Mental reversals are easy, as one learns by working with the ground-glass screen of a camera. Copperplate engravers have to work in reverse, although Meryon, the etcher of Le Stryge, the Devil of Notre Dame, who himself died insane, is said to have turned his back on the view and worked from a small mirror.

In ordinary writing with the right hand the little finger goes first. If a left hand writes with the same muscular movements, the little finger going first, mirrored script is the result. By experience the left-hander usually corrects this. He writes by a wholly different set of muscular actions producing a correctly oriented imitation of script by the right hand, as in the case of children whose right hand has been crippled before school age. Testing children in writing

with the left hand they should write, however badly, correctly oriented.

When this correction has not been spontaneously attained, during ordinary school-life, strong suspicion of subnormal mentality is aroused. In the case of children with speech defects persistence of mirror script on attempting writing with the left hand justifies a very guarded prognosis as to hopes of improvement.

Speech and Left-handedness.—The relation of speech to left-handedness is not clear. Stammering is said occasionally to be set up by attempting to correct left- to right-handed work. I have never seen it happen. Cases are quoted of supposed cure of stammering by training to left-hand work, although in none does suggestion seem to have been considered. No case of speech defect is ever mentioned as a sequel of amputation or paralysis of the right hand.

In pure sinistrals one would not expect excess of speech defects, but in the dextrosinistrals, who make up the mass of lowered dextrality, there should be considerable excess of nervous signs including speech defects, squints, and mental subnormality.

Ballard in 51 pure sinistrals among 11,939 children found none with speech defect. In 271 dextrosinistrals, whom he took to have been educated out of their sinistrality, but whom we take to be the mass with impaired dextrality, he found 46 with existing and 24 with past speech defects. His proportions of stammerers were 1·2 per cent. right-handed, 1·1 left-handed, and 4·3 dextrosinistrals. In the special schools, no left-handers, 2·4 right-handers, and 19 per cent. dextrosinistrals.

J. E. W. Wallin, in St. Louis, states: "The vast majority of our left-handed pupils who had been taught to write with the right hand had not developed any speech defect."

Mrs. Scripture classifies 25 per cent. of 500 cases of speech defect as either left-handed themselves or in their families. She is apparently under the impression, although not stated, that right-brainedness plays a part in speech defects. Some of the explanations she quotes cannot be accepted, as, for instance, the young man with word-blindness and stuttering cured by reversing the hand (*Laryngoscope*, 1917. 157).

Franklin Jones believes transfer from one hand to the other has grave risk of stammering. Only 1 per cent. of pure left-handers he finds stammer, but with transfer about twenty times as many (*A Study of Handedness*).

Claiborne advocates training the left hand in stammerers. Where the condition is not due to mental defect, when it may be expected to remain unrelieved, any effect is almost certainly the result of repeated suggestion. Young fiddlers do not become stammerers.

My own conclusion is that in pure left-handedness there does not

appear any disposition to speech defects, but that in case of poor dextrality, associated defects, speech among others, are commoner than the average, whilst the evidence of any close connection between direct production of speech defect and stress from educational training of the hand is quite negligible (*S.H.*, 1920. 39).

Ambidextral Training.—Education is subject to violent crazes (or stunts), which arise, flourish, and disappear. Such was the ambidextral craze a generation ago. It, however, gave the schools the idea and practice of free-arm drawing, not yet properly appreciated in all its educational bearings. Children were encouraged to do symmetrical drawings, the left mirroring the right. The work was valuable in helping the youngest children to develop semi-automatic actions, and in making teachers better appreciate the rôle of kinæsthetic work in education. Left-handedness has always aroused much interest, and the literature of the subject is enormous.

There was even an Ambidextral Society, where others, gifted mostly with a high degree of dextrality, assumed that they could develop the right side of the brain by training the left hand, a physiological misapprehension of which they made much. If the stammering theory just mentioned had had any reality, they should have produced much speech disturbance. There is physiological economy in high attainment of skill on one side, not likely to be attained if spread over both sides.

Educational Treatment.—The ease with which children learn capital letters seems related to the greater proportion of simple up and down strokes. Script or print writing avoids complicated lateral movements, and is easily learned by young children.

In left-handedness a sound diagnosis is important. Pure left-handedness with other indications of left-brainedness such as fixation by left eye, kicking with left foot, parting hair on right, would probably give the easiest result from allowing the left to be used.

Indiana has a law of 1916 that "for left-handed pupils seats and desks may be placed so as to permit the light to fall over the right shoulder." With a good brain and well-developed dextrality it will be an advantage if early right-handedness is encouraged for common and essential acts. The defectively developed and partially left-handed may be dangerous when rapid actions or right-handed tools or controls are concerned.

Caille, in a paper on the subject (*Trans. Am. Ped. Soc.*, 1921. 352), advises that training of the right should be encouraged but not too much pushed in inveterate cases.

Schaefer, who investigated the subject in the Berlin schools in 1909, found 4·06 per cent. affected, and thought they should be educated separately. There were enough to fill twelve schools (*Int. Arch. f. Sch. Hyg.*, viii. 447). Ambidextrous training was attempted in Berlin, but given up (1913).

It is the so-called ambidextral children, or ambisinisters as they would be better described, whose dextrality needs developing. Let it remain ambidextrous but train the right hand as much as possible. This is one of the cases where attempts at developing a specific and abnormal individuality would make a child a nuisance. For the ordinary purposes of life, such as the use of tools, mostly made for the right-handed, the proper course is to develop dextrality by using the right hand. It takes learners fourteen days in the classes at Copenhagen to learn to saw, bore, or hammer with either hand.

In the ordinary physical exercises which are mostly symmetrical, any want of readiness in co-ordination, want of rhythm, and any ocular difficulties in a left-hander would seem to call chiefly for balance exercises, frequent and short rather than continuous or prolonged efforts. Walking the plank first on the flat, then sloped, is within the capacity of the smallest child in the school. In the matter of games the left-hander will at first be at a great disadvantage. It is useful and important where the community or herd depends upon every member, that each one should be able to respond smartly to the rule of the road, whatever it may be, or to play the game like his fellows in the right way.

CHAPTER XXXIV

MEDICAL INSPECTION AND TREATMENT

Medical Inspection and Treatment.—Improvement in the health of the younger members of the community is indubitable. It is due in some measure to medical service which in the last thirty-three years has grown up in the schools. Medical inspection and treatment of school children is not enough. Practically, all our crippling is permitted ; millions of children are robbed of their earliest days of happiness ; underfed, badly housed, without space to run or play ; badly clothed, and without medical oversight, sometimes until death is in sight. This is the lot of the majority of pre-school children all the time, and of many school children most of the time.

Medical service in schools according to the basis on which it is reckoned is unsatisfactory, in that either cost is too great for the result, or the result is insufficient for expenditure, and incompletely covers school-life. As the Americans would say, we want to sell health to all the people, and make them realize its worth, but we tinker with disease.

Instead of an examination at long intervals, there ought to be an annual inspection by the school doctors ; if this is deemed too much for the results, then the ideal school scheme would be a frequent screening of children by the teacher, who would presently value health, and teach others to do so also. The teacher's first selection would again be reviewed by the school nurse, and her selection by the doctor. Efficiency by this scheme would be doubled or trebled, and probably the cost less than halved. It could always be checked by occasional detailed examination of all in certain schools or sections.

There are indications (*Seventeenth Report M.O. Board of Education*) that enquiries are being made which will lead to these methods of working and result in great popularizing of health. At the same time, intensive observation on small numbers will lead to the acquirement of necessary accurate scientific knowledge, whether of healthy development and its variations, or of the effects of schooling or beginnings of disease.

This side of the work has had but little attention.

Medical inspection was made a general requirement by Section 13

of the Administrative Provisions Act, 1907. It is now statutory under Regulations No. 19 (1925) of the Education Act, 1921.

The duty of the Authority is to arrange for attending to the health and physical condition, and to provide for medical inspection of elementary school children about the time of admission to school and on such other occasions (after attaining the age of 8, and again after 12, or as leavers) as the Minister of Health may direct. The same duty extends to other pupils under 18 years of age in higher educational establishments under the Authority, or if requested by the managers of such establishments when not provided or aided by the authority. These pupils have to be examined in the term of admission, and each year afterwards.

Treatment has naturally followed the requirement of inspection, as an arrangement for attending to health and physical condition which must include following up of causes of defect, the detection and prevention of uncleanliness, and medical treatment of defects of eyes, teeth, minor ailments, and enlarged tonsils or adenoids.

The official schedule for examination records ought to be as short as possible. Half the doctor's time is taken up in detailed examination of healthy children, and another quarter, perhaps, in recording trivial defects which elsewhere would be unnoticed.

The twenty-four headings of the schedule (see p. 634) could scarcely be reduced advantageously. These headings are stated to be the minimum requirement for efficient inspection; in many ways they thus fix a standard sometimes excluding efficiency, as, for instance, weighing children on only three occasions in their school-life. The one really serious omission, probably due to political reasons, is the absence of any record of vaccination.

The examination has to be conducted during school hours and on school premises.

The usual routine is for the hour and date of inspection to be fixed some weeks beforehand. It is known that about twenty to twenty-five pupils can be satisfactorily handled at a session. The pupils for each examination are selected according to their status by the teacher, and their cards filled up with items for recognition under I. The school nurse fills in those under II, and weighs and measures the child. She also examines (8) cleanliness, and generally (11) vision testing and (14) hearing. The parents are given notice and invited to attend at the time fixed.

The actual examination finds the doctor in the medical officer's or nurse's room selected for the purpose. He is seated at a table with his back to a good diffused light, and with places on his right for the child and its mother. The child should face the light. If this is too high, oral and nasal inspection will be difficult. Roof lighting is the worst. Each child comes in separately and should be undressed to the waist by the nurse or teacher, and its boots removed

before coming to the doctor's table. The cards must not get mixed. The child has therefore to be recognized from the card. "Is this Johnny Smith ?" will be the first question. Meanwhile there is a rapid general survey of the *tout ensemble* of both child and mother.

SCHEDULE OF MEDICAL INSPECTION.

I. Name..... Date of birth .....
Address ..... School .....

II. *Personal History (Vaccination ?).*
(*a*) Previous illnesses of child (before admission).
Measles. Whooping-cough. Chicken-pox. Scarlet-fever.
Other illnesses.
(*b*) Family history, if exceptional.
1. Date of inspection.
2. Standard and regularity of attendance.
3. Age of child in years and months.
4. Clothing and footgear.

III. *General Conditions.*
5. Height.
6. Weight.
7. Nutrition.
8. Cleanliness and condition of skin. Head. Body.

IV. *Special Conditions.*
9. Teeth.
10. Nose and throat. Tonsils. Adenoids. Submax. cervical glands.
11. External eye disease.
12. Vision. R. L.
13. Ear disease.
14. Hearing.
15. Speech.
16. Mental condition.

V. *Disease or Deformity.*
17. Heart and circulation.
18. Lungs.
19. Nervous system.
20. Tuberculosis.
21. Rickets.
22. Deformities, spinal disease, etc.
23. Infections or contagious disease.
24. Other disease or defects.

Medical Officer's Initials.

General observations.
Directions to parent or teacher.

Nutrition is judged by shadows on the chest, and by a gentle grasp of the forearm; tongue and teeth are quickly examined; tonsils and pharynx noted. A wooden tongue depressor used, is then thrown in the waste basket. Each ear is looked at for obvious

discharge, and the finger-tips swept round the submaxillary regions. The eyes are inspected, the lower lid being depressed if necessary. The chest is auscultated, and then the child stands up, and turns round, its posture, spine and feet being noticed.

When any condition suggests detailed examination—for instance, by eye, ear, or nasal specula—the best method is to put the child on the list for an inspection clinic later, and see it at leisure and free from the rush of routine inspection. Those who go to clinics or hospitals should be reinspected at the end of three months.

Details under the various headings of the examination will be found on other pages.

All entries on the inspection card must be made whilst the child is present, if error is to be avoided. The mother should be informed of any condition which she may be able to get relieved, and if necessary an advice card for treatment should be given to her. When the parent is not present, the school nurse will take charge of this for due delivery.

In some places, a Care Committee member or organizer is present to make arrangements for treatment. Except for clerical assistance, they are excrescences on the system, and when charges are abolished should be swept out. They should not be present in the examination-room, only the child and its mother, doctor, nurse, and teacher being needed. Any others will interfere with the privacy of the work; they can only give aid at second hand, and they seriously hinder the inspection and its amenities.

With entrants, examination must be done most circumspectly. Formerly the child would come up very much alive to the various preparations, and especially when told "He won't hurt you," or "Don't be afraid," the youngster was often full of unknown apprehensions and very little would make it cry, when all the others within earshot would also be frightened. However, nowadays, the child has often learned so much, and may even have played at "medical inspection," so it may come up, and sitting down thrust out its tongue at once, or reply "ninety-nine" to a question.

Making a child touch its nose, or point out its ear, or shew two fingers, usually establishes friendly relationship; then it will shew its teeth, or how long its tongue is, and so on. The child who keeps its hand held out till it is told to put it down, or sticks its tongue out till it is told to shut its mouth, is wanting in spontaneity and often dull mentally.

In the examination of scholars or candidates, it would be well to have a published statement of health conditions held desirable in candidates for scholarships or higher education at the public expense. This would become useful propaganda as a standard of

health to be reached and maintained by all children. A useful scheme would be on the following lines—

1. No child shall be reported fit who is not likely to remain in good health during the tenure of the scholarship, or who has any defect or deformity which will be objectionable in school, or will materially interfere with benefit being derived from the scholarship now or in later life.

2. In case of doubt of the health of any prospective candidate, an application for medical examination should be made to the school medical officer at the earliest possible date.

3. If treatment for remedial defect discovered at examination be neglected, the candidate will run the risk of rejection at the scholarship medical examination.

4. Causes for rejection as unfit are—

(*a*) Offensive or purulent discharges, particularly of eye, ear or nose; tubercular disease in active forms; rheumatic heart disease, or certain chronic skin or nervous diseases.

(*b*) Chronic oral sepsis or untreated active dental caries.

(*c*) Impairment of hearing or of vision (using both eyes) beyond $\frac{6}{9}$ acuity, e.g. block letters half an inch high to be read at 20 ft., using glasses if necessary.

(*d*) Junior scholars who require correction exceeding 4 D. in any meridian in the better eye, to be rejected. In particular cases normal vision may be required.

(*e*) No scholar shall be reported fit whose condition shews habitual neglect of personal cleanliness, or whose clothes or hair show traces of vermin, apart from accidental infections.

Boy artificers for the Navy must be as near perfection as can be got; practically any defect disqualifies. Height must not be less than 61 in. and the chest 31 in.

Certain defects may raise difficulties. Flat-feet have to be judged on the whole circumstances of the child. Hammer-toes will exclude from occupations where the candidate has much standing, or needs to climb about, in such occupations as the building trades, engineering or seafaring trades. In these also hernia is a bar. Undescended testicle, when met in a boy before puberty, should be disregarded, as it may come right, but at later ages it is rare, and its liability to inflammation or even new growth may then make operation worth consideration. Varicocele depends entirely on the degree, the general condition, and the occupation suggested. Where hernia is well kept in position by a truss no action need be taken, but it should be a disqualification for work entailing much activity or strength.

Out of School Employment.—Work out of school has been so curtailed that there should be little resulting harm. Chapter VIII of the Education Act, 1921, deals with this. By-laws can be made by the Education Authority prohibiting any employment by children under 14 in any specified occupation, or defining the ages or hours in which any employment may be permitted. The same may be done for children up to 16, employed under an individual licence for street trading. No child under 12 can be employed

during school hours, or before 6 a.m. or after 8 p.m., and no child below 14 for more than two hours on Sundays.

92 (2) defines that a child under the age of fourteen shall not be employed (*a*) in street trading; (*b*) to lift, carry, or move anything so heavy as to be likely to cause injury to the child; (*c*) in any occupation likely to be injurious to his life, limb, health or education, regard being had to his physical condition.

The Education Authority is also empowered to prevent any employment detrimental to the child in any way, and an employer has to furnish the Educational Authority with any particulars of employment they may require.

Decision as to the nature of employment is on a medical certificate furnished to the employer by the Educational Authority, and this certificate is held to be evidence in any later proceeding.

A very few children, "theatre children," are employed in entertainments. A precocious neurotic, often rheumatic child, seems to be frequent among them. They must be over 12 years of age, and fitted for the employment, which can only be followed if duly licensed by the Education Authority. The issue of the licence is usually hedged about by innumerable formalities, so that the way for exploitation of children is not made easy.

In matters of school attendance the school medical officer often examines absentee children as to fitness for attendance, but this is no part of the duty of the authority. Any medical certificate of unfitness has to be furnished by the parent, as shewing why he is not discharging the duty of ensuring attendance.

It was from the writer's action in regard to such certificates that our whole system of medical inspection originated.

Attendance of the children in primary schools averages 88 to 90 per cent. Coughs, colds, bronchitis, account for about a third of the absences. The excess is most marked in better class and residential districts. About a tenth are due to zymotics, and about a sixth unconnected with illness.

Children out of school for long periods should have their certificates examined by the school doctor every three months. Rheumatism here takes first place, accounting for about a fifth of the absence; tubercular diseases nearly as much; diseases of the eyes, ringworm, each account for about 7 per cent. The absences are equal in boys and girls to about the age of 11. After this age, absent girls are so useful at home that they set free other workers, and the result is they outnumber the boys considerably.

Minor Ailments.—Many minor ailments are now treated at clinics established for this purpose. Children are sent up, and parents accompany them, and there is the whole organization of different variety of cards, and Care Committee organizers at work.

The system is admirable, but extremely wasteful in actual expense, as well as in the time of officials and parents. The cases in four out of five children are trivial—impetigo, septic sores, nail in heel of boot, foreign body in eye, discharging ears and so on. A nurse manages most of the work, a doctor attending some of the sessions. The actual cost is reckoned as 7s. 6d. a case ; it should not exceed 2s.

An efficiency engineer would at once point out that there is a 70 or 80 per cent. waste in this service, and that it can only be done cheaply and effectively by the school nurse in the school. After all, a herd of sheep get more regular medical attention from the farmer's men, in respect of minor ailments, than double the number of children would do in school from those who have charge of them.

Treatment Centres are being steadily organized for the "school diseases," the chief matters being operative work in connection with tonsils and adenoids, ophthalmic work and refractions, and the various skin conditions. The work here is on the ordinary basis of an hospital out-patient room, but each case must be seen throughout to the end. The dental clinic should be associated, but so far as operating-rooms are concerned, separate from the rest of the arrangements.

There is advantage in a northern aspect for dental operation-rooms, to secure absence of strong shadows, and heat in Summer.

With anæsthetics, the atmosphere gets almost intolerable in a room facing the south.

The same waiting-room can serve the ordinary clinic and dental clinic, but the exit from this last should not go through the waiting-room. It should be separated, out of earshot of the waiting-room, and should have a recovery- or rinsing-room.

An obstacle in the way of insisting on treatment is the clause—modelled on the objectionable feeding clause, and carried forward from previous legislation—81 (1) of the Education Act, 1921 : "There should be charged to the parent of every child or young person in respect of any treatment provided for that child or young person such an amount not exceeding the cost of treatment as may be determined by the local Education Authority."

Some absurd results have come out; thus, the first instance taken at random is *Heston and Hounslow Report*, 1920, where the charge is based on the family income. Under 8s. per head less rent, nothing is charged for tonsils and adenoids operation, then the charge rises with the family income till when it is 12s. per head less rent, the charge is 31s. 6d.

The cost of treatment for a large city may be reckoned by the cost per case : for minor ailments, 7s. 6d. ; for ear, nose or throat, 8s. 4d. ; vision, 5s. 6d. ; teeth, 7s. ; and ringworm, 25s. (1925).

Before the War the cost of recovery of these charges exceeded the charges recovered in London, and as late as 1921 less than 5 per cent. of the expense of treatment was recovered; the expense of collecting representing 143 per cent. of the amount recovered, or taking Cheshire for the same period, £94 was received for £7742 expended.

It is evident that this charging process is not worth the cost, and yet it is deterrent of treatment. The charges might be reduced to a nominal shilling, as for dental care in London, where the cost is about 5s. 6d., but still it is deterrent, probably reducing dental work in London schools by half. This shilling, again, can be reduced to a penny, but the objectionable habit remains, and the cost of accounting for it, with all the voluntary inquisitors.

The clinic will always have a drag on it so long as any charge remains.

CHAPTER XXXV

SCHOOL NURSING

The London School Nursing Service, for which the writer was responsible for many years from its inception, presents most problems on which a school nursing service should be organized.

A London School Nurses' Association started in 1898 : they advocated use of the spare time of Jubilee nurses in the schools. These two or three good Samaritans attended sore heels and inflamed eyes, and in early days in London one occasionally came across a sporadic nurse at work. The children were lined up smiling and happy, glad if they could find a cut or bruise that wanted attention, and to get out of class into the queue. The work was purely charitable and thoroughly popular with youngsters, but scarcely educational in outlook or results, and in no way a public service, or part of school-work.

In 1901 the London School Board appointed a nurse to secure improved attendance of children by diminishing ringworm among them. She was given four districts representing 300,000 pupils.

Cleanliness and its opposite were unobserved, and no one heeded till the doctor and the nurse made unpleasantness about it. Miss Margaret McMillan was a pioneer in cleansing campaigns, which began in Bradford and soon spread. She writes : " In the middle 'nineties the condition of the children was indescribable. At the first bathing centre the children had to stand on large sheets of paper while they were being undressed."

The London staff of nurses increased, and their duties multiplied. They are still school visiting nurses with many schools under care. A cleansing scheme, intended as a demonstration for benefit of teachers and administrators, was being worked in different parts of London. It was not a permanent educational arrangement, but was, unfortunately,—against the wish of the School Medical Officer—adopted in an L.C.C. Act and then in the Children Act of 1908. Intended as a demonstration, it was not educational, as a penal process the end is defeated. It takes up too much of the nurses' time in travelling.

All other workers—nurses, visitors, or social helpers—are striving without sound foundation until the school nurse has penetrated the

home with her educational gospel of personal cleanliness. Fines and penalties are offensive to anyone; indeed, they set up opposition, in a negative attitude, compared with subtler methods by which the trained nurse reaches out to her aim of a 100 per cent. clean heads in the girls' school.

When the school doctor got to work, filling up cards of children at the rate of 25 to 30 a session, the work was impossible without help of teachers and nurses. The enormous waste of time has been partly relieved by transfer to the nurse. The nurse also goes through cards made out by the doctor after the inspection is finished, and fills in a statistical form of results. She may have other work too, in connection with treatment cards which have to be filled up and delivered to parents.

In London the nurse carries a bag containing a lotion bowl, an aluminium comb, a spirit lamp to sterilize her forceps, and a magnifying glass, also a mackintosh cloth and supplies of the cards and various forms for returns, together with stationery. It is the minimum, and will have to remain so until proper school cupboards are equipped with these necessaries.

Experience in her ringworm work gives the nurse accuracy in diagnosis. From the first, the laboratory has stood behind her, and there was only one positive test accepted, the finding of spores of the fungus. Yet, after nurses had been five years at work, there remained opposition. In one case where money was actually paid to compensate a claimant, at next opportunity the nurse was proved to be correct. In another case, managers sent a deputation to the Authority complaining of the nurse's action. One doctor took a case into court and lost the case, after the court had referred the matter to the skin specialist of the London Hospital. No case ever succeeded against the nurse's findings. Of 363 successive medical certificates contesting the correctness of the nurses' diagnosis in as many cases, the laboratory only failed to demonstrate spores in twelve. It was therefore assumed that in ringworm the nurse's positive diagnosis was reliable for all practical purposes, error shewn by the stringent check of laboratory tests being only 3 per cent.

Favus, a particularly resistant form of fungus, was prevalent in the East End of London, and in 1906 a school was opened with 60 of these cases in attendance. In two years the assiduous work of the nurses cleared the district, and ultimately the school was closed. For favus and ringworm the school nurse is indisputably best means of prevention.

For scabies her diagnostic powers are equally good, but this disorder before the War was to be regarded as a family disease. The school nurse can do nothing beyond notification to the Sanitary Authority and the exclusion of affected children. Disease is limited

to a few families, and their existence is an index of inefficiency of the Sanitary Authority.

The absence of a health conscience which allows continued prevalence in such matters is a defect or failure of the Education Authority, remedied by instruction in school, supplemented by the school nurse instructing in the home. These last considerations also apply to vermin, in form of lice or nits in heads or clothes. Vermin-hunting is a futile proceeding whilst homes are too dark to see conditions, and water has to be carried from the basement up many stairs. Here again, the school nurse may become an intermediary : she can assess conditions, and get results where obtainable. The existence of vermin is only important as an indication of popular acceptance of their existence as a normal part of life.

The next extensive work the nurse was tried on was discharging ears. Foolish efforts to farm out public work as cheaply as possible had begun, and employment of part-time Jubilee nurses instead of school nurses under our own direction and management, made the scheme such a modified success that it was soon abandoned (*L.C.C. M.O. Educ. Report*, 1909. 43).

The need for specially trained school nurses was becoming apparent. Such a school nurse can handle outbreaks of conjunctivitis and blepharitis. She can recognize cases to be seen by the doctor, and take responsibility of decisions which a teacher could not be expected to make. There are other ophthalmic, otological, and orthopædic cases, where her decision is of value.

The teacher should do routine testing of visual acuity in all cases, and should test the child's hearing, where this is possible, to be assured that it is sufficient for school purposes. All doubtful cases should pass to the school nurse.

Cases of truants and unruly children should be seen by, and talked to by, the nurse. Her independent position probably will have as great effect as that of anyone in school, and her skill in handling patients will come in.

At pre-school ages, and in the nursery school, the ordinary trained teacher, except as an administrative officer, is almost to be feared. The school nurse is more important here. Probably for all pre-school and nursery school arrangements a trained nurse would be preferable to any other person as head in charge of arrangements.

It has been suggested that girls intending later to train as nurses might with advantage spend the period between leaving school at 16, and entry to hospital work at 20, on the staff of nursery schools. They would be the right kind of workers and at the best age to act as helpers for infant children, for the nursery school staff should always be on the young side of life.

In schools full responsibility must be placed on someone for

daily supervision of sanitary condition of all parts of the schools. This should be as assiduously regarded as is the condition of one's home. Provision of drinking water, washing arrangements, soap and towels, and, above all, the condition of lavatories and closets and their furnishings are essentials which a few teachers attend to, but generally the existing conditions are not creditable to educational ideals. All this responsibility should be definitely placed on the school nurse, to make independent reports of conditions needing amendment, both to the central office and in the school log-book. That this is needed is seen from a head master recently contesting the position with a medical officer and declaring that boys should not have soap or towels, or be allowed to wash their hands in school, although the wash-basins were there.

The management of infectious diseases is chiefly a matter of striking early, and here again, in such a matter as measles, the control of the school nurse to-day is better than a whole sanitary department to-morrow. Philadelphia found "a saving of nearly five days in every case of infectious disease with the school nurse's services. This represents a saving of over one-third the cost of the nursing service" (*Buffalo Congress Report*, 1913. 1. 153).

The feeding of children and proper ritual of the dining-table should be under her supervision. Nutrition, hunger, diet, necessary provision of milk, should be entirely on her responsibility, always with reference, of course, to the school doctor. Above all, these things should be wholly removed from interference of outsiders. They depend on the condition of the child, and on no other condition. C.O.S. ideals here are hypocrisy.

The squalid ideals of social service set forth by so-called Municipal Societies, in their sordid and selfish policy as a guide in public affairs, need crushing in merciless fashion wherever they present themselves. All who are inspired by such policy are opposed to—and at every step have opposed—progress in the public duty of improving health of the children and amenities of their lives. Only properly trained and sufficiently paid workers are adequate for this public social service.

In London, owing possibly to the School Service being transferred to the final control of a Medical Officer of Health, the preposterous condition was set up of having Care Committee organizers or their assistants present at inspections and treatment centres to hear the advice given by the doctor to the parents as to the after-care of the children.

The nurse must do more than mere school supervision. Conditions of foot-gear and clothing, posture and gait should be within her province. She should have all pre-school children on her list from the age of 2, and see them from time to time in regular supervision, to refer them to school clinics if she has any doubt of their

condition. The nurse, again, has a large field in treatment of the various conditions classed as minor ailments. She can keep in touch here, and refer them to the doctor when necessary. Children for treatment should have their cards on her treatment file, to remain there until she can discharge them, as having had the necessary care at clinic, hospital, or elsewhere. She alone should have the responsibility of this "following up," and be responsible to the doctor for its efficiency.

Under no circumstances should the nurse ever collect payments of money. That last proviso is essential for her status as an independent helper in the homes.

Here is a wide field, not to be picked up easily by mere apprenticeship. Two years in hospital work chiefly in out-patient rooms and children's wards, and then a definite school hygiene course, embracing handling of cases with uncleanliness or disease. The sanitary conditions of buildings, some knowledge of skin, eye, throat, and ear and orthopædic work, conditions of nutrition and good feeding, milk, sunshine, fresh air, sleep and play, tooth-brush and handkerchief drills and many other details, of which the nurse has gradually to get a knowledge and ability to supervise.

The school nurse, too, is best of all in dealing with the personal hygiene—more often defective than is suspected—in secondary girls' schools. It is this school girl who is the real health missioner to the home whilst at the age when she is constructing for herself a working ideal of life.

Each school nurse, high or low, must accept full responsibility for all decisions she makes. Those she is unable to decide must be referred at once to the school doctor, but a nurse of senior grade may advise in the interim. Each school should have a room or surgery in charge of the school nurse where medical inspections and any treatment is done. This is a necessary requirement in every school, with hot and cold water and the standard furnishings.

Medical records of examinations and treatment should be here, available for use at any moment. She should teach the children to make their own records, and attend to their own physique.

In utilization of the nurse's possibilities American cities have advanced considerably beyond English. The nurse's room, or health room, as a requirement has to be provided in many cities, in every school (Fig. 124).

Boston requires such a room 200 to 400 sq. ft., with outside lighting, the door to the corridor to be marked "nurse's room." The walls have to be a smooth plaster finish, with rounded corners, the lower wall one-third glazed with white tiles to the floor, the upper part painted a light green. The floors of first-class terazza construction, or composition for second class. An electric socket for hand lamp, and a pendant electrolier. A nurse's closet, 3 × 4 ft.

deep, with one shelf for supplies, and six hooks for clothing. A bath tub, and five porcelain enamel bowls. Bowl with hot and cold water faucets, with shampoo cock. A gas or electric heater and a clock. The furniture is a medical cabinet for instruments, drugs, and dressings, dressing-table, white enamelled frame, glass top and shelf, with rubber crutch tips. A revolving stool, filing case for 1000 cards 4 × 6, a writing-table, chair, couch, and a mirror set over the bowl.

With her responsibilities and increasing importance, the status of the school nurse must be considered if the proper type of woman is to be obtained. The highest class obtainable is only really satisfactory. Her status in any school must be equal to the teachers',

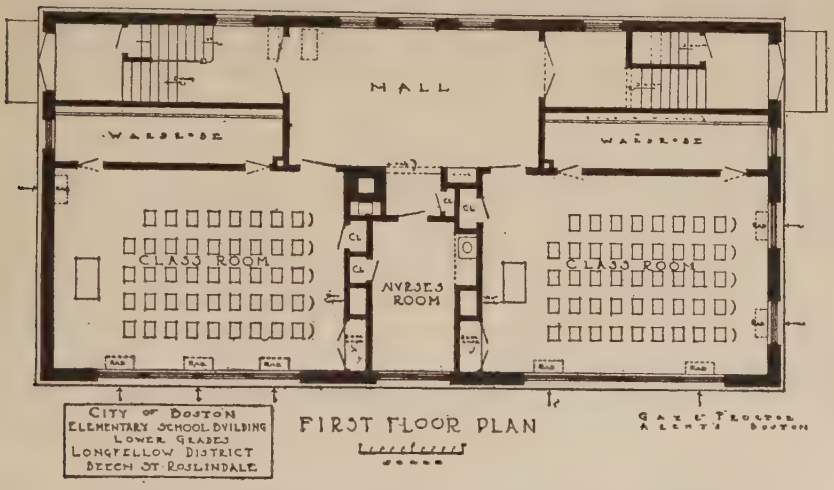


FIG. 124.—NURSE'S ROOM IN AN AMERICAN SCHOOL.

except, of course, the head of the school. In many ways, she must be independent of the head.

Nothing is said about the nurse as attendance officer, in which position she would often be better than a man. Leaving this out of consideration, for a nurse to undertake the necessary requirements, she should have few departments. Anything embracing a roll of over 1500 pupils would be excessive in a town ; in a country district this would require further reduction. The only place for the untrained social workers would be as helpers, for enquiries under direction of school nurses.

The numbers of school nurses will have to be increased, their areas greatly diminished, and their remuneration must be at least equal to the teachers'. In London they have never been adequately paid. The original nurses under the London School Board and L.C.C. were women of considerable capacity and had outstanding

qualities which made for success, but under a new regime the miserable conditions of pay were not improved as expected, and naturally there was wastage and the quality of service suffered. Perhaps they became more discouraged when they found the work they were most fitted to do taken out of their hands and camouflaged by untrained voluntary workers. These have destroyed effective touch of school doctors and nurses with the homes, and greatly discounted the School Medical Service as a health-promoting agency in the community. A specially trained nurse would have all their knowledge, and in the homes be generally welcomed instead of being considered an impertinent intruder.

Training of the School Nurse.—More than two years' hospital ward experience is waste time for what is wanted in the school nurse. A preliminary general education, with three or four months' student work in fundamentals of physics, chemistry, anatomy, and physiology, sufficient to make her hospital work intelligible from the first, should during this time be accompanied by work in out-patient rooms.

The nurse's great asset over other social workers is her capacity for handling and managing her fellow-creatures under all sorts of conditions, her mode of approach, her sympathetic attention to irrelevant troubles, and her decisions where others do not know what to do. The nurse's uniform is a guarantee of this, which makes her generally welcomed as an honest and disinterested friend, who has help to give, and will give it freely and fully. Her work in the wards should not preclude her from still seeing a good deal of the out-patients, and her curriculum should be arranged so that she does not remain too long at the same kind of work.

The school nurse in the last eight months of her training should specialize and pay particular attention to conditions of posture, physique, and nutrition, to testing of vision, and the fit of glasses, to signs and symptoms of infectious diseases. She ought to gain some acquaintance with the purposes of the schools, particularly infant, nursery, and pre-school conditions, and see something of the homes. She would include the work of the Health Visitor and the Care Committee organizer in the day's work.

Nothing has been said of other varieties of nurses ; the dental nurse should become established in precisely the same manner as a dental hygienist in relation to school dentistry ; there, New Zealand has set us a good example.

A supply of such school nurses will only be obtained if properly paid. At present living rates, this would correspond to not less than £200 a year, clear of all other expenses, contributions, or uniforms.

The school nurse promises an escape from the present costly and relatively wasteful system of medical inspection. She could be at

once set on to do pre-school care of children, and select any departures from health that should be seen by doctors.

For public purposes, there is no corresponding advantage derived from the routine inspection of normal children three times in their school lives by the doctors. All the futile weighings and measurings on which thousands of pounds have been spent have given no corresponding public value. The testing of each eye separately, with 20 to 30 per cent. error in some classes and nothing effective to remedy the conditions, requires such methods to be thrown overboard.

Teachers could be trained to do much of this work with great advantage to themselves and the children, and better in ultimate educational and health results to the public than the present system. The nurses are actually doing some of it now. They could with definite directions do the whole routine work as well as it is now done. After a few weeks' special training, having the school doctor behind them for all doubtful cases, the risk of error would be negligible, and the saving in cost great. The matter of " putting it over " to the general public in the way of propaganda by the nurse would be an advantage greater still.

The school nurse with the enhanced views here taken of her possibilities represents an immediate step. It is intensely practical, it is very economical, it attains the highest general level for which the community is ready. It will give results commensurate with the cost, and relieve some from the feeling that much money is being wasted on treating symptoms rather than causes.

CHAPTER XXXVI

HEALTH OF TEACHERS

The teacher stands well to the top of the list of good lives. He and the parson have days that are long on the earth, compared with other people, but the teachers' suicide rate (22) is a trifle above average (19). These facts, in a way, epitomize the whole story.

No statistics present a sufficiently reliable figure of present conditions. They serve merely to indicate some points.

Half a century experience of the Gotha Life Insurance Company shewed that comparative mortalities of German men were : All males 1000, Secondary teachers 835, Clergy 859, Primary teachers 875—this in towns being 843 and in country 889 (*Zeit. f. Schulg.*, 1908. 250).

In England, taking all males as 1000, the Registrar-General gives the comparative mortality of teachers as : 1861–71 it was 1032, 1880–2 as 782, 1890–2 as 660, and 1900–2 only 583, whilst by 1911 it was just half, or 506.

In Holland, similarly, whilst all males were 820, teachers were 567, clergy 670, doctors 1034. In the last Decennial Supplement, undisturbed by abnormality of War, the Registrar-General states that at every age the man teacher is better than males generally.

Table 84.

ENGLAND AND WALES, 1911.

Mortality per 1000.	15–	20–	25–	35–	45–	55–	65–
All males	2·20	3·52	4·71	7·94	14·65	30·04	94·32
Teachers, active or retired	1·68	3·43	2·61	4·10	8·96	23·07	75·53

During 1904–18 the London death-rate among teachers generally was 3·63 per 1000.

The illnesses that are suffered by teachers and prevent work are not many. This is true everywhere.

In Dresden, 1906–9, average absence was 8·36 days each ; but 46 cases represented 3973 days, whilst 587 cases only represented 1322,

or 2·5 days each. In Mannheim, 1900–10, men had 3·67 and women 9·93 days' absence yearly.

In Leipzig, when it was proposed to raise hours of work, an enquiry shewed the percentages returned, not entirely unbiased, as in poor health—

Age	20–	25–	30–	35–	40–	50 or more.
Percentage ..	20·3	35·3	41·2	49·0	49·4	52·0

Professor W. H. Burnham, by a questionnaire, in 1904 attempted to find out the relation of American schools to teachers' health, and got replies from teachers indicating that 37 per cent. had damaged health. Of these, 10·8 per cent. attributed it to poor ventilation, 9·6 to bad lighting, 7·4 to nervous strain, 4·0 to long standing, 2·8 to outside noise, 2·6 to overcrowding, and 2·0 to chalk dust.

In London, 1904–19, the mean illness of men was 4·6, of single women 8·2, and of married women 9·3 days (excluding maternity absences). When one analyses out a number of record cards, it is surprising how many cases shew up as regular attenders year in year out without a failure, but a few skrimshankers appear. One good lady in twenty-one years had contrived an average absence of thirty-four days a year so cleverly that she had never been referred to the doctor and had been paid for 486 days not worked.

From Hart's analysis (*Roy. Stat. Soc.*, March 1922), in which 76,258 years of service were considered, roughly speaking in any one year half the teachers are not absent at all, a third are absent once, and a seventh twice. In relation to maternity absences, which were not included, it is noteworthy that whilst there is about 1 birth annually to every 9 married women in London, there is only 1 to 40 married teachers.

The illness per year of service 1904–18 in London was—

Table 85.

Age group ..	21–25.	26–30.	31–35.	36–40.	41–45.	45–50.	50–55.	56–60.	61–65.
Men	4·3	4·1	2·8	2·8	3·5	4·0	5·5	5·8	9·2
Women, single ..	6·4	6·9	8·6	8·7	9·1	10·9	15·1	10·4	19·1
Women, married ..	11·1	8·5	7·1	8·2	9·0	9·7	11·7	13·1	19·6

Experience of the Teachers' Provident Society, which covers about a third of the teachers, was that there was little illness (see Table 86).

The medical selection of teachers should result in a good mental and physical stock. A certain number, which Sir S. Russell Wells

in the House of Commons (March 31, 1923) called second class, are selected as bursars about 13 to 14 years of age. Others are selected from scholarship holders.

Good general physique should be looked for, and a candidate not accepted, if more than 10 per cent. below the average measurements for age, as already set out in the chapter on Growth and Physique. Personal cleanliness should be a high standard. There should be no aural discharge, and any case with a suspicion of deafness, thinned or indrawn tympanic membranes or prominent malleus handle, should be closely questioned as to hearing, wooliness or tinnitus. Many of these cases causing much trouble in their school-work twelve to fifteen years later. The nasal passages should be healthy and clean. Articulation should be perfect; any lisp or sigmatism of the slightest kind is a cause for rejection. Enlargement of cervical glands, or unhealthy tonsils, and granular throat, require attention, noting and warning, lest this be a cause of rejection later. Vision should be

TABLE 86.

DAYS OF SICKNESS.

	1904–8.	1909–13.	1914–8.
Men	3·28	3·40	4·69
Women	4·49	4·95	6·02

normal. Slight corneal haziness seen by oblique illumination or even maculæ which reduce vision a trifle may be neglected if $\frac{6}{9}$ and $\frac{6}{12}$ can be got in the two eyes respectively. Otherwise the rules of the ophthalmologists (p. 517) should be strictly applied in respect to candidates for teaching.

For other conditions ordinary Life Insurance rules for first-class lives may be taken as standard. Tuberculosis, even as a suspicion, should cause rejection.

A pulse-rate habitually over 100 is a cause of rejection. If fine tremors of fingers are associated with rapid pulse, it is well to carefully observe lest a larval case of Graves's disease be missed. Von Graefe's or Stellwag's eye symptoms mean a rejection. Many girls, however, after a month or two adjust themselves completely in regard to pulse-rate, although for a time they may shew varying feverishness, and have an erethic emotional disposition. Boys, too, in place of this, may present a nervous heart at puberty which will clear up in a month or two. Anyhow, if any doubt exists, it is better to reject for teaching now than later.

When the secondary school period is over, and admission to

training college is sought, candidates should be rigorously examined, as they have been now some years under observation, and the girl who turns up with nits in her hair is not the kind of person wanted as a teacher. Grossly neglected teeth should also be given not more than one chance. The stature should not be less than 5 ft.—that is probably too small. It is not right to children or teacher to pass a diminutive person. A girl of 18 or 19 with varicose veins in her legs is to be unhesitatingly rejected. There is a heavy type of girl, apparently due to some endocrine condition, and often myopic, in whom this condition is likely to be found. A tendency to flat-foot or hammer-toe or any marked scoliosis is a handicap, considering the amount of standing.

Eliminate the phthinoid type, with a small thorax and long limbs. The enteroptotic individual is a nuisance in school or in later life, and, when seen, should be refused.

A young woman who does not play games, and cannot swim, will make a poor teacher later. Anything like absence due to nervous breakdown, frequent headaches, pronounced dysmenorrhœa, tremors, hysterical behaviour, the slightest suspicion of any kind of epilepsy, or nervous signs such as nail-biting, should stand in the way of acceptance.

Next to perfect hearing, the condition of voice is important. A girl who has had a loss of voice, or speaks in a whispering way, or with pronounced mannerism, should be rejected. An occasional case is seen with dry, cracked eczematous condition of the hands, and as this is likely to be aggravated by chalk, they should be noted and warned from the start.

Rheumatic fever, and chorea, if there are any cardiac results, are definite cases for rejection. Sometimes one is tempted to pass them if there is no evident cardiac complication. Still, any family history of acute rheumatism, or rheumatic heart disease, should be a cause for rejection.

A boy of 14 made a good recovery from rheumatism, entered training college, grew a fine fellow 6 ft. high, played in the football team, had a recurrence of the rheumatism, and was permanently invalided with aortic disease a few days before taking his certificate examination. Another almost similar case ended fatally six weeks after discharge from college. They are always doubtful cases, but everything has to be taken into consideration, as they have also a livelihood to gain.

An unfortunate condition one comes across occasionally is where a miserable, underfed, emaciated, and debilitated child, whose parent, perhaps an equally under-nourished widow, wants to make a teacher of the child, who has been given a bursary. It is almost obvious that the child will not keep up against such odds. The environment is hopelessly against it, and yet it is in a way an

injustice to refuse the opportunities. This can be met by the doctor stating his opinion and referring it to the Educational Authority for action.

The physical standard must be kept high, and teachers who try to pass pupils as good scholars, who are inferior animals, are not behaving loyally to their profession.

Pulmonary Tuberculosis.—One disorder may be taken by itself. Pulmonary tuberculosis is spoken of as the teachers' disease. The age most liable to development of phthisis is late adolescence, but in teachers, probably due to the elimination of likely cases at entrance, the selective age for appearance is delayed till about 27 to 32 years of age. In the past the emaciated coughing school teacher was a recognized character in fiction, but scarcely to be noticed now.

French writers have insisted on the great frequency of tuberculosis. Brouardel is quoted as saying that a fifth of French urban teachers are tuberculous (*Nuremberg Congress*, 1907. i. 160), and that even in the country—Brittany, for instance—it is very bad. Calmette (*La Med. Scol.*, ii. 41) states that this is due to defective school sanitation.

A saner outlook is that of L. Gourichon, who found scarcely 5 per cent. with signs, and most of these closed cases. In the Department of the Seine only 1 per cent. of absence is credited to phthisis (*London Congress*, 1907. 683). It appeared somewhat worse in secondary schools, being 5·77 per cent.

Meierhofer, who analysed Swiss teachers' returns, 1912–14 (*Schw. Bl. f. Schulg.*, 1915. 49), thought phthisis (1·3 per cent.) rare, and Kraft in Zurich worked out comparative phthisis mortality of teachers as 11, whilst the general population was 25. A Swedish tuberculosis committee found 5·88 per cent. masters, and 11·78 per cent. mistresses affected by tuberculosis (*Ped. Skrift*, 1911. 57).

The ascription of tuberculosis as the cause of pension or death is often very doubtful. Some years ago, on the basis of pension and mortality records, a bad record was made out for the Düsseldorf district, but Schurman, going over the records again, corrected all this. He could not check the dead, but of 37 living pensioners recorded as tuberculous he found only two that could be placed in this category, and stated the teachers' risk here was of the smallest (*Klin. Jahrb. B.*, 25).

So far experience cited has been foreign, and may be summed as shewing that where there are heated and badly ventilated school-rooms they may contribute to phthisis.

One English writer at the 1907 School Hygiene Congress in London (*Trans.*, 686), Dr. Oldwright of Toronto, writing on the school-room as a factor in tuberculosis, took a very gloomy view, and placed women teachers' mortality as equal to printers, and

above stonemasons or publicans. His figures, however, are for Canadian and American cities, and have not been corrected in any way for the average youthfulness of their teachers, nor allowance made for the way in which many there leave in early middle life to take up other employment.

English records are strangely silent on the subject. Beyond the reduction in English mortality shewn by the Registrar-General's figures already quoted, there is nothing.

A Committee of the N.U.T. which wished to save the heavy cost on their provident funds from protracted cases, and attempted to investigate the subject, applied to many authorities, but found that nowhere was any record available (1919). They attempted to work out an estimate based on several lines of reasoning, all of which gave about 1 per cent. as the proportion of teacher population affected by phthisis.

Absences of Teachers with Pulmonary Tuberculosis.—When the writer came to London he found many chronic phthisis cases working in schools, out a few weeks perhaps with hæmoptysis, and then back again at work. To prevent this a regulation known as the "Twelve months' rule" was instituted, which permitted a teacher to have leave of absence up to twelve months, and if before that time certified fit to resume, he or she could do so, otherwise the appointment lapsed. This rule was very beneficial for securing the teacher's interests, and was occasionally applied in other chronic cases.

About 1919 the Board of Education instituted a rule that "A teacher who has been reported to be suffering from pulmonary tuberculosis should be required to abstain from teaching. She should be informed that she cannot be recognized in any capacity until six months after the submission of a medical certificate shewing that the disease has been arrested, and then only on a further medical certificate stating that the improvement in the general and local physical condition has been maintained; that the teacher is free from all signs of active tuberculosis, and that in the opinion of the medical officer making the report she is likely to be able to render permanent service as a teacher."

In a way, this is a good rule, but it is not discriminating enough, in that a teacher who formerly would at once be told he or she was threatened with possible tuberculosis, is not now certified as such, but is put down as catarrh, bronchitis, pleurodynia, pleurisy, and so on. To those who carry out a course of treatment approved by the medical officer, the authorities generally pay full salary for six months excluding holidays, and half salary for another six months, as any leave without pay would not count for pensionable service.

There ought to be some distinction made between suspicious

cases and those with open tuberculosis. No doubt it will come in time. Certain cases are now allowed to resume in open-air schools. A teacher with unmistakable phthisis would be well advised to give up school-work permanently, and should, as under the Danish Act of 1905, be pensionable with two-thirds of the salary unless in other public employment, in which case the pension is correspondingly reduced. The writer, with enormous experience, could number on his fingers the teachers who have had leave for pulmonary tuberculosis, and permanently resumed school-work to do well for three years afterwards.

Teachers in England have no special risk of phthisis if they live an ordinary life, and pay attention to the simplest rules of hygienic dieting and exercising which so many disregard.

Among teachers laryngitis formerly appears to have been common. A dry, inflamed throat with a weak, scarcely usable voice was the prominent feature. Greville MacDonald mentioned a case where a teacher had managed a class of 120 for seven years, and at that time 70 pupils in a class seemed not unusual. It was then remarked that in the United States where classes were restricted to 40, the trouble in teachers was not known.

Milligan of Manchester gave a description (*B.M.J.*, 1895. ii), under the title of "Teachers' laryngitis," of a chronic catarrhal condition of the vocal cords, with paresis of certain muscles and limited varicose conditions on the true cords. In advanced cases there were small nodes of roughness on the edge of the cords. Yonge (*B.M.J.*, 1897. ii. 807) described about 45 per cent. of women teachers as presenting some degree of change, but only two out of 70 had nodes.

The conditions were generally put down to straining of voice by pupil teachers. Why these conditions are specifically described as teachers' laryngitis seems doubtful. The whole picture is common in other classes of the community, and scarcely more frequent in teachers than in other voice users. Of recent years it has become, even in its slight degrees, less common among teachers than formerly. Classes are restricted in numbers. Younger teachers have had instruction in voice production, and teaching is not usually carried on now with several classes in one room, which was very common in voluntary schools, being the plan on which the old Church school was built.

Voice hygiene, the use of an unhurried and unforced low-pitched voice, still remains the duty of every teacher, on their own account as well as for the sake of their pupils. Ill-health or debility may originate an attack, or where there is a slight degree, a little stiffness or sense of exertion in a neurotic girl, some extra strain, may easily precipitate a complete functional aphonia. For any functional failure of voice, at least a month of rest and general stimu-

lating and tonic change to the seaside or Switzerland is to be recommended.

Neurasthenia.—The disease which is the bugbear of disciplined workers, and especially incident on teachers, steadily becoming evident at earlier ages and in more pronounced forms, is chronic neurasthenia. For this reason the neurotic candidate, however clever at bookwork, should have every obstacle put in the way of joining the profession. It is predisposed by the teacher's life. It is the educational organization that tends to restrain expression of individuality and personality. It makes the work monotonous and full of tedium. The teacher before a class knows no relaxation. His behaviour, clothes, gestures, voice, everything he does is under constant control. The teacher who has to teach children more than they can understand, and has a constant stream of regulations, circulars, advice notes, instructions, and forms to be attended to, remembered and followed, has a low-grade strain which exhausts his higher capacities.

Again, for many, as Stanley Hall recorded, "Knowing already all he has to teach, he is liable to lose incentive, until his mind becomes indurated and essentially indocile. Both ease, wont, and routine slowly close upon his soul, and restrict the area of plasticity and vital growth. Once he was progressive, but he has stiffened in the mould. He is master of his own technique to such an extent that it has almost become busy work."

Gradually many become over-attentive, meticulous, and even suspicious; they watch gestures, think over remarks, and drift into a condition of almost reflex sensitiveness, near allied to neurasthenia, and unfitting them for the give and take of school.

The routine so gets hold of some that they cannot face a change of the slightest kind. Transfer to another department may be a crisis. "I am only used to Standard III, and can teach no other," wrote a selected candidate to the appointing committee.

An infants head mistress consulted the writer because the chief speaker at a prize distribution had praised the boys and girls of the school and had not mentioned the infants. This she held to be an intentional slur on her capacity.

On the top of all their strains and stresses many pay little attention to hygiene. Others are chronically poisoned by low septic conditions. They may have tiresome daily journeyings and a miserable midday meal. They may have dropped interests in the way of hobbies or recreations, and take but little exercise. Women are great offenders here, both in respect to diet, particularly lack of green vegetables, and also want of sufficient outdoor exercise. Stagnation, mental and physical, is the average teacher's risk. It invites neurasthenia from any unwonted strain. Alcohol as a stimulation is a fatal refuge for the woman, but fortunately offenders

become fewer every year. All kinds of social engagements and recreations should almost be a religion with the teacher.

Financial matters used to be a large factor, but they need be so no longer. In the past ten years the teachers have had this remedied beyond any other class of school worker. Still, more and more sleep badly, worry over their work, do not leave it behind in the school. They lose nervous poise, get emotional, and express over action by gesture or voice. Often they have headaches, indigestion, constipation, or other organic worries. They get tired, and wearied with it all, and some trivial incident may precipitate a neurasthenic attack.

A teacher's work is not individual, as is that of the doctor. The school is worked by a team. They are all colleagues, although one may be the leader and organizer. The newly promoted head mistress too often begins by assessing the weakest members of the staff for replacement. It is for her own glory, although she rationalizes this into the idea that it will benefit education. Unless she is prepared to say that a teacher should be dismissed from the profession altogether, she is behaving disloyally to a colleague. It should be scored up as a mark against her record. So far as the writer can judge from the statements, one-sided though they may be, head mistresses of this driving type are the cause of much unnecessary distress, and the worst offenders against colleagues often older than themselves.. The teachers' organizations should keep a very watchful eye on new brooms and the staff changes within the succeeding months. A higher development of standards of ethical behaviour would aid in diminishing neurasthenia, but this is hardly the place for its discussion. It is extraordinary how often one comes across teachers in the distress of ill-health, with no union, and no provident fund at their back. One of the chief means of avoiding nervous anxieties, if not actual breakdown, is the consciousness of support of colleagues given by membership of a great organization.

The hygiene and amenities of school require standardizing by the professional organizations, and insistence on provision of such things as common rooms, and privacy, hot and cold water, comfortable furniture, and private lockers for clothes and other articles. If properly advised, these organizations could lay down and obtain standard requirements, in accord with definite specifications for all the members.

The conditions of the class-rooms should also be levelled up ; for instance, they should refuse to allow a teacher to work in a room when she faced a window all day, or in a room with the temperature below 45° F. Teachers' complaints should go confidentially through their organization. This would do much for education, and indirectly raise professional status. It is questionable whether these organ-

izations should not make themselves responsible for the teaching efficiency of all schools in their district, and save the cost of other officials, and take away the petty interference of ignorant laymen in the control of details which they do not understand. Education needs reducing in its pressure on teachers by making it less academic and more physical. The teachers should become interested in children's bodies as well as their intellect. Good physique has an abiding interest for teachers themselves. If they are to enjoy life they must have vitality, and vitality also makes personality.

These are the lines along which the prevention of neurasthenia can be laid. It is not only the breakdowns, but ten times as many who struggle along, handicapped by mental discomforts and miseries, and who are a danger to pupils under them, perhaps as dangerous in other ways, as would be a chronic consumptive in the school.

The anxiety complex is common after a few years' service among the women. Its relief comes through social sublimation. Young ones who begin to question whether life is worth living should join clubs, go to dances, and leave all the details of school in the school-room.

The teacher who is ill is generally well treated, and a visit to the Medical Officer is more likely to be helpful than something to be feared. The doctor has a duty to the Authority and to the school, to protect them against failure, against infectious disease, or even against the person who seeks advantage at the expense of others. He is also there to protect the teacher, sometimes from outsiders, sometimes from other workers, sometimes from themselves. He will often act as a useful counsellor, send them to consult their union, or suggest a doctor or specialist. His only interest is to see them fit again, not to let them return unfit. He sometimes has a difficult rôle. He sees troubles coming that are not yet fully apparent. He has to be a good listener. Many of the teachers he sees are very self-centred, some are suspicious, others reticent. Some mental cases present little evidence of trouble. They are on guard till something may slip out accidentally. The worst are those who out of some trivial incident build up a logical and coherent grievance which dominates their whole conduct. Where there are any doubts, a holiday is often a great solvent, either dispersing the trouble or making it evident.

Every one seen is a purely medical case. No pains must be spared in investigation, and every help given to bring about recovery. The doctor's report is not on medical aspects, but deals solely with the teacher's capacity to carry on now or at some definite date. The report must carry all the finality possible or justifiable. A hedging report is discreditable. The common degenerative diseases have to be searched for carefully. Whatever the decision may be,

it should be clear. The record of the facts on which it is based should be accurately made at the time. Sometimes it is advisable to read it over to the teacher so that he or she may realize the position.

The writer has probably examined more teachers in serious conditions than anyone, but he has scarcely ever had to alter the tenor of a report, and never had to give evidence in court over any disputed case.

CHAPTER XXXVII

INFECTIOUS DISEASES

Infectious Diseases Generally.—Infectious diseases are the reaction of the body to invasion by living organisms of different kinds. Common examples are ringworm or scabies, scarlet-fever or measles.

In the case of scabies, the organism, an acarus, is an animal about a fiftieth of an inch long and just visible to the naked eye. The ringworms or favus are due to fungi easily seen with the microscope, and reactions of different intensities may occur.

Variations in prevalence and infectivity of the common ringworm suggest a careful study that might throw light on diffusion of diseases due to subtler forms of life. It is only during the growing period that ringworm persists, for in adults it fails to maintain an existence.

Causes of various infectious diseases are not so easily recognized as is the fungus of ringworm. Some are well known, some are doubtfully known, and the existence of others has only been recognized by deductions from effects observed.

These diseases breed true in that infection from one case of disease can only cause another case of a similar disease. Isolated symptoms as feverishness, headache, and so forth may be common to many diseases, and due to numerous different varieties of organisms, but any particular disease as a whole is due to some particular species of organism. It is possible for a mixed infection to take place and thus for diseases to be simultaneous or overlapping. There are enormous varieties of micro-organisms, but few possess dangerous properties. Indeed, large numbers are either useful, or harmlessly associated with our lives.

Anthrax affords a good illustration of the general mechanism of infection. A man who was a wool sorter, one Sunday afternoon, thought he had been stung by a gnat on the side of his neck. The following evening he was seen in consultation. There was a " boil " with a black crust nearly the size of a threepenny-piece, and four or five yellowish vesicles around it, on an inflamed red area about the size of a florin—the " malignant pustule." The patient was extremely ill, in a state of high fever, temperature 104° F., and with rapid pulse. His head and neck, and body to the epigastrium, were

swollen and œdematous. Some fluid removed from one clear vesicle contained rod-shaped anthrax bacilli, some of which were seen in the process of digestion by leucocytes. Anthrax bacilli had established themselves in the pustule and were being attacked and destroyed by leucocytes, but they were also throwing out toxins into the tissues at such a rate that the lymphatic and capillary circulation over half the body was interfered with, œdema and high fever resulting. The malignant pustule was cut out by a couple of deep elliptical incisions. It was hoped that all bacilli were thus removed and that the body would be able to deal with the soluble toxins already in the tissues. When the patient was seen next morning, fever had fallen to 99° F., the pulse quietened, œdema gone, and rapid recovery followed. Later, microscopic examination of tissue removed by operation shewed central pustules crowded with anthrax bacilli, but the rest of the tissue was free from them.

This gives a working idea of the general plan of an infection. There is an infective dose of germs, which manage to establish themselves in a local area. During a certain period of incubation their presence is scarcely felt. Then begins an invasion. The germs throw out toxins and an accumulation of leucocytes—" leucocytosis "—occurs to meet, digest, and destroy the invaders. The other body cells react to the toxins by fever, quickened pulse, œdema, and so on. They also produce antitoxins carried in the blood plasma. If leucocytosis and antitoxin production is sufficient, the germs and their toxins are destroyed, the body has attained immunity, and recovered.

The result of malignant pustule was often death, from insufficient immunity being attained in time. Removal of the local source by operation, in the case detailed, was early enough to avoid this, and body cells made short work of toxins already distributed.

This process has been presented diagrammatically, as there are many varieties and details, often not yet understood, in the way in which different infections establish themselves, and in the reaction which takes place.

The mode of infection, however it may vary in details, follows a general scheme of invasion by germs. These settle locally at a primary focus, primary lesion, or portal of access, as it is termed. Many germs, in catarrhs or zymotics, for instance, apparently infect the naso-pharynx. Rheumatism, poliomyelitis, and encephalitis germs also may enter here. Others enter through the mouth, or infect intestinal surfaces, and any mucous surface may be a portal for infection.

When thus established, the products of germ activities are various chemical materials, ferments or toxins. Some of these are retained in the micro-organisms as endotoxins. There are also the proteins of the germs themselves, often poisonous. Both these

varieties of substances are liberated on destruction of germs, and may cause symptoms of poisoning. Many micro-organisms excrete toxins (exotoxins). The process of inflammation means that numerous leucocytes are stimulated and crowd about the germs, destroying them by phagocytosis. There are also secretions in opsonins and antitoxic substances, produced by other body cells, and existing in variable amounts in body fluids, which either render the germs more susceptible to action of the leucocytes or neutralize their poisons.

The outcome of infection depends on which is most powerful locally, germs and their toxins, or opsonins, leucocytes and antitoxic products of the body. Where the body cells and fluids predominate there is said to be a high degree of immunity; if the bacteria prevail for a time, they are said to be virulent, and the body to have poor immunity.

The horny surface of skin epithelium is the first defence. The common skin germs which may occasionally penetrate have not time to well establish themselves, and throw out their poisons around, ere leucocytes crowd up and destroy them, without any noticeable effect locally, beyond perhaps a little pustule. When immunity is low, from starvation or overwork, or defective excretion, the process may be tardy, and feeble debilitated children are prone to chronic sores. Even athletes in training, who sacrifice everything to muscular efficiency, have a diminished immunity, and the skin cocci often are able to cause numerous and recurrent boils.

A scratch or cut should heal without trouble. Sometimes when contaminated by foreign material, germs may be enabled to establish themselves dangerously. Wounds fouled by cultivated earth are notorious for tetanus infection. This germ was first discovered in the victims who were injured in the soil, by falling of a church in a Riviera earthquake. Injuries or scratches at post-mortems, or during operations on septic cases, are notoriously severe, or even fatal. The organism, usually comparatively innocuous, here is accompanied with a large supply of its toxin, and gets established before the body tissues can meet the dose. Tetanus germs, washed before injection, do not infect laboratory animals, as they do if unwashed.

The amount of dose is an important factor in infection. A hundred bacilli will be destroyed where a thousand might establish themselves. Massive doses are the danger, and there is a minimum infective dose. A dose may be massive enough to overthrow all defensive mechanisms. An undergraduate packed up one evening to return to the University next day, but ere that day was over he was dead of "measles." At a school visit a child was seen who had vomited that afternoon; she was taken home, and was dead at 5 o'clock next morning with malignant scarlatina. One Friday

afternoon an infant just admitted for the first time that day was brought out as the teacher noticed a rash. It was indeterminate, but she was sent home. On Monday morning a postcard stated "there have been seven cases in the class," and three died. Diphtheria had been unknown in the district for many years.

A repeated small dose at intervals of time sufficient for body tissues to deal with each dose, before another one recurs, develops the power of resistance. The cells are thus educated to produce the required antibodies and establish immunity.

This was worked out empirically for rabies, a disease in which the micro-organism has not yet been isolated. Pasteur found that virulence of rabies, as measured by time of incubation, could be more than doubled by passing it through rabbits. He then found that spinal cords of rabbits in which the virus is mainly present gradually lost their infective virulence if preserved *in vacuo*, and at the end of three weeks infective power was gone. By inoculating material taken from such a non-infective cord, which caused no infection, and then a day or two later from a more recent cord, which still had slight virulence, this now did not infect, and it was possible to work back, till tolerance was established for material of even enhanced virulence, which could be then inoculated without infecting. The animal had acquired active immunity through repeated injections with mitigated virus in gradually increasing strength.

Smallpox, another disease of which the germ has not been isolated, was earlier discovered by Jenner to be mitigated by passage through calves, so that its inoculation in vaccination protected against the virulent forms of smallpox. This also is an active immunity which is possessed by the cells, and may last for years.

The body tissues by such processes are educated up to the necessary means of resistance.

Another form of immunity is where cells have not time to be educated, but where they can be helped. This is done by adding to body fluids the specific antitoxins which counteract the disease. In the typical case of diphtheria, a horse is actively immunized by repeated inoculations of increasing amount and virulence, until its blood serum contains large quantities of antitoxin. If some of this strongly antitoxic serum is injected into an individual, there is enormous gain in the ordinary immunity, and if already infected, this temporary passive immunity may help the patient to overcome disease at once, or keep it at bay whilst his own cells develop active immunity required for further protection. Where individuals are naturally exposed to occasional and repeated small doses of infections, which do not become established as disease, nevertheless the body cells are educated and acquire an active immunity, from their readiness to deal with the germs. The active natural immunity is partly hereditary and partly acquired.

The comparative immunity of town populations in outbreaks of zymotics, compared with rural populations, is due to urban dwellers so repeatedly being exposed to small doses of infection. So, too, nurses and doctors acquire high degrees of immunity, particularly in fever hospitals. Continued existence of slight amounts of a disease in a community is thus helpful as a kind of insurance at small cost against violent epidemic outbreaks.

Each person encounters pathogenic germs every hour of life, and maintenance of health or breakdown in illness depends on their reaction to these germs.

Surgeon-Commander S. F. Dudley (*Lancet*, 1924. i. 1141), in a study of diphtheria and scarlet-fever, attempted to analyse the factors by comparing rate of infection with rate of defence. These rates introduce a time factor, so following him, an hour may be used as a unit.

We do not know how many germs are needed to infect, once the defences of the body are overcome. The minimum lethal dose usually spoken of, is the dose L, sufficient to overcome all defences, and definitely establish infection.

If the average dose of germs hourly is V, and protective mechanisms can destroy U in an hour, infection will not take place if U exceeds V. The individual can be continuously exposed without risk. Probably, indeed, a heightened immunity will be acquired. If V is greater than U, then the hourly dose not dealt with is V—U, and infection will occur in $\frac{L}{V-U}$ hours.

From his observations on naval schoolboys at Greenwich, Dudley concluded that this period of infection was over one, but less than ten hours, under the conditions there prevailing. He follows out other conclusions which this explains. Droplets, in coughing, can carry from 30 to 40 ft., but wards full of coughing children can be treated without infection occurring, in beds 9 to 12 ft. apart. Infection, it may be concluded, is received at a low rate and in low concentration at these distances.

If infection travelled in straight lines, the dose would diminish with square of the distance from origin, but it has to be distributed through space, and at that rate, if evenly distributed, would diminish in intensity as cube of the distance. In practice, the rate will be somewhere between the two, so that in a dormitory where the rate of infection is already V—U, by doubling the distance between the beds, the rate of infection would be reduced to somewhere between $\frac{V}{4}-U$ and $\frac{V}{8}-U$.

Whatever scatters the dose, as in good ventilation, will further diminish V. Where the atmosphere is hot and moist, the droplets do not evaporate and may carry farther; the individual's own

resisting capacity may be affected, so that temporarily U is diminished, and therefore the (V—U) increases, and time for infection is shortened. Carrying this plan of velocity of infection in mind, many problems are aided in solution.

Air itself as a medium for the conveyance of infection is negligible. Surgeons have long since abandoned the carbolic spray intended to destroy germs of the air in which they worked. Sewer air, when free from splashing, has been shewn free from pathogenic organisms. There are no air-borne diseases. An odd germ here or there would do good. It takes millions to infect.

The commonest infective diseases of school children can be treated in open wards without serious risk of cross infection, if insured against contact risks.

Air as a vehicle of infection has been reviewed by Dr. C. V. Chapin (*J.A.M.A.*, 1914. i. 423), and "spacing out" is recognized as one of the best prophylactics (Glover, *B.M.J.*, 1918. ii. 509). Flooding buildings with fresh air may have a drying effect; otherwise, in the absence of human beings, ventilation has no particular disinfecting value, in the sense that soap and water disinfect.

Where patients are spraying out infective droplets in a comparatively small room, good ventilation may serve by thinning out such spray to a degree below the risk of massive infection, thus serving to mitigate the dose received by others.

In the contest with infectious diseases, to get the maximum benefit to the population, we must try to arrange things so that rate of infection V always remains less than rate of defence U.

The ancient idea was that the cause of the disease, *materies morbi*, must be kept at a distance—nothing else mattered. The result was cordons and quarantines. These still have a limited utility in dealing with uncivilized races, and persist in some forms, as the placarding of infected houses in America, to see which makes one think of the mediæval methods of the Great Plague years.

Quarantine by muzzling and isolation of imported dogs has been successful in freeing the United Kingdom from rabies; this is, perhaps, the most successful example in existence. The next step was tracing out the routes of infection.

Quarantine did not prevent malaria or yellow fever, but interfering with the life cycle of insect carriers has practically ended these as epidemics.

The exploration of the mechanisms of disease resulting in Pasteur's remedy for rabies led on to other means such as the Behring serum for diphtheria, and all the various sera and vaccines by which active or passive immunity can be conveyed at a greater rate than infection.

The healthy carrier of disease germs in parasitic form first came to demonstration through the study of diphtheria.

The explanation of typhoid fever as an accompaniment of armies in the field became evident. Apparently normal carriers of this disease in the ordinary circumstances of life are almost harmless, but when crowded together in army tents they become conveyers of infective doses to those associated with them. Probably carriers in this sense are many times more numerous than sufferers, in all infective diseases.

The effects of overcrowding are made evident by outbreaks of disease which would not have otherwise been noticeable. Dudley's work has a considerable bearing here.

Effects of crowding in War shelters during air raids were supposed to be shewn by increased voracity of fleas, and in sickness returns (*L.C.C. Report*, 1917. 38), but no real effect was noticeable in the short periods of crowding. The diseases scarlatina and diphtheria are not good indicators. Measles or whooping-cough might possibly be expected to shew something, but the contacts were too diluted by adults. The carrier under good sanitary conditions is probably more beneficial than harmful, especially to children, in the maintenance of public health. The ordinary school-room conditions will be referred to later under holiday influence, and adult carriers must always be considered links in the chain which carries on these childish diseases.

There are healthy carriers in whom there is no illness; their mechanisms for immunity are so good that the germs they harbour do no harm to them. The germs are merely parasites, and survive because they are on the body, but relatively not in it. The body cells and fluids scarcely reach these germs, and they continue to exist.

Primary carriers, in large numbers, are in all communities, and may only be carriers for a short time; for instance, the carriers of the meningococcus do not seem to harbour it much longer than actual sufferers. On the other hand, there may be more rarely chronic carriers.

Newsholme wrote of chronic diphtheria and chronic scarlatina in 1902, describing carriers, with various kinds of discharges originating in these diseases. These were really secondary carriers, in that they had had disease, and still harboured the germs.

A body of knowledge regarding infections has been acquired. It cannot be fully utilized by rules and regulations. Education of each individual will reach far beyond any inspections or regulations, but mere knowledge here is not sufficient without the emotional drive of a community spirit to make the individual seek health for his fellows as well as himself. Even in school-days this is applicable; in later years it becomes perhaps the most important of all considerations to the chronically infectious case.

There are not only many carriers, but always much slight or latent infectious disease, silently occurring in the population.

When epidemics come, the carriers are so numerous that the ordinary prophylactic measures can scarcely be kept up. On the other side of the picture is the advantage to the community of carriers who do not shed lethal, but immunizing doses, thereby gradually protecting their younger associates. It is of value to each, to acquire some specific immunity. It is also of value to build up physique and nutrition to such an extent that the individual is always ready to react in the most complete way to any invasion and to protect against all depressing circumstances.

There seem to be long series of secular variation in diseases, which it is not proposed to discuss, in what the old writer called the epidemic constitution of the disease. Smallpox was spoken of as a comparatively mild disease, then our grandfathers knew it as a fulminating horror, from which only vaccination saved them. Now it appears to be reverting to mild type, interspersed with a virulent type, here and there. So, too, scarlet-fever is gradually becoming milder. On the other hand, epidemic encephalitis and poliomyelitis seem lately to have been in the stage of increasing severity.

There is an epidemic cycle, which had not yet been analysed out, but which one can say depends on several factors, of which the most influential will be, nature of the disease, age, constitution, and space distribution of the population.

This brings measles around in peaks in the large towns every two or three years, scarlatina in peaks, varying from four to seven years. In isolated or widely spread districts these are spread out, so that adult life may be reached without experiencing measles, and it may come on the heaped-up inflammable material like a devouring fire. Parts of the Scottish Highlands, and the Faroe Islands, have had such experiences. The Danish Government wisely prevents casual visitors to Greenland on account of risk of conveyance of infection to an unresisting population.

Comparing year after year, it is found that there is an annual curve of incidence. It is not fixed for the zymotics as for catarrhal and pulmonary diseases. Whooping-cough belongs mainly to the Spring, but diphtheria seems to tend to a prevalence in the Winter, measles in the Winter and Spring, and scarlatina in the late Autumn and early Spring in London. In Chicago, the variation is roughly similar.

From figures extending over ten years (Cohn, *Z.*, 1905. 63), in Berlin, Breslau, and Munich, diphtheria behaves similarly ; and scarlet fever shews a preponderance in the Autumn ; whilst measles has a June and December excess in Berlin ; the Breslau children shew great excess in June, and the Munich excess is at Christmas. Measles is perhaps the most variable as regards season and place.

In America they attempt to estimate the expectancy of these

diseases, the median, not average, of the previous nine years being taken as the expectancy. Adjustment is made to correct for any secular variation, placing beginning and end years about the middle of a cycle, not too high or too low. The trend of disease is indicated by a slow increase towards expectancy for weeks or months before it assumes epidemic form. In Massachusetts they speak of an "endemic index" which is the average for five years, exclusive of epidemics. This is applied to each city and town for each month. Far away the easiest of all methods is simply to keep the weekly curve of cases notified, and of deaths from the disease.

Gottstein (Berlin, *Klin. Woch.*, 1896, No. 17) suggested a "contagion index," by which he means the percentage of non-immune persons who are infected when exposed. He gives the "contagion index" of measles as 95, of scarlatina as 4, and of diphtheria as 1. The index corresponds to the course of the epidemic curve. Steep for measles, protracted over months for scarlet-fever, and stretched for years for diphtheria, one takes it that these are inversely as the tendency to numbers of healthy carriers in the population.

Priestly has pointed out a numerical relation between numbers of cases notified, which is another way of expressing the contagion index.

The first definite impression of the study of school cases was that every child in the community would have measles sometime, and that an optimum time was to be striven for. The next was that probably 80 per cent. would escape scarlatina, which recent years have confirmed.

Immunity to some of these diseases is literally sucked in with the mother's milk. Erlich shewed this by immunizing mice to abrin and other poisons which act like the zymotic toxins. Hamburgher determined that the mice of a normal mother could be immunized by an immunized foster-mother. Hence mothers should nurse their children. Bottles have no immunity to confer.

Infection is almost a corollary of civilized life. Speaking in the most general way of the zymotics, the child is born with a certain capacity for resistance. This may be a matter of hereditary acquirement. It is an active immunity, but it is not very great in any case. There are families which seem to acquire all that is going, just as others escape everything.

Duguid, who studied the conditions minutely in a congested district of Birmingham, where less than 4 per cent. children escape all zymotics before they leave school, notes immune families. "In some families it was most striking, several families of seven and nine children having passed through childhood without one of them having contracted any of the diseases" (*Journ. of S.H. and P.E.*, Autumn, 1924).

The suckling also acquires some immunity from its mother. She has acquired this in the ordinary way through contact with minimal

doses or even suffering the disease, and has the specific toxin in her blood. This the child acquires in some degree either placental, antenatal, or in nursing after birth. In any case it is a passive immunity and soon lost. It then becomes for the next few years, as an infant and a toddler, exceedingly susceptible to infection. The sheltered child whose orbit is small may escape for years. The child who is constantly coming into contact with others is liable to infection, and in cases where massive infection is the rule, as measles, will probably soon suffer. In cases where smaller infectious doses are more common, as scarlatina or diphtheria, he will acquire a certain amount of immunity; especially if he is a member of a family of children, and is unlikely to suffer unless an extra massive dose comes his way. The only child, the first-born, or the protected child of higher social rank—these may escape the acquirement of protective degrees of immunity, and go out into school-life ready to fall by the first big dose they meet.

Dr. Ewart (*J. of Hyg.*, Jan. 1916. 208) wrote a statistical paper on the influence of the age of the parent and zymotic diseases, in which he shewed small concordant correlations for zymotics (except smallpox and chicken-pox), and concluded that infectious diseases attack the earlier born at younger ages. This is in agreement with the natural history given above.

The numbers of deaths in England and Wales were stated in Parliament, for the years 1915–24 as, influenza 252,299, measles 70,992, whooping-cough 54,722, scarlet-fever 12,794, encephalitis lethargica 3,796, chicken-pox 812, and smallpox 146; so that all other zymotics are insignificant beside measles and whooping-cough.

The United States Public Health Service note that the curve of increase of those who have had zymotics rises rapidly to about 13 or 14, then slows down to the horizontal, except mumps, which continues to rise till about 19 years old (*Pub. Health Rep.*, June 1924. 1566).

The occurrence of disease before and during school-life may be taken from Gloucestershire for the ten years 1908–18. Entering school by 5 years old, the record of what happened is—

Table 87.

GLOUCESTERSHIRE.

	Pre-School.	During School.	Total Numbers.	Percentage.
Measles	38·4	40·6	24,333	79·0
Whooping-cough ..	25·4	19·4	13,811	44·8
Chicken-pox	15·0	15·1	9290	30·1
Scarlatina	3·9	8·1	3697	12·0
Diphtheria	1·2	3·3	1371	4·4

A similar record made for 17,000 children in Kent in 1912 shews the variations in percentages previously attacked which may be expected—

TABLE 88.

KENT COUNTY, 1912.

	Aged 5.		Aged 6.		Aged 13.	
	Boys.	Girls.	Boys.	Girls.	Boys.	Girls.
Measles	48	49	51	48	83	85
Whooping-cough ..	37	42	41	43	50	53
Chicken-pox	20	23	21	22	30	35
Diphtheria	0·8	1·2	3	1·6	4	5
Scarlatina	2	3	4	3	9	11
Mumps	1·5	1·5	1·6	1·3	6	5

In Berlin, where the children enter at 6 years old, the entrants investigated by Schultz (*J. f. Kinderf.*, 1908. 184) during two years shewed that there had already suffered, measles 68 per cent., whooping-cough 35 per cent., scarlatina 15 per cent., and diphtheria 7·0, which is a worse incidence than in Kent or Gloucestershire, and for the last two diseases worse at the beginning of school-life than in the English school at the end. These figures are supposed to be taken out at the regular school inspection, but in practice the records of the M.I. cards are found faulty when outbreaks occur.

Detroit furnishes a very complete record of the percentage of cases in each year for the first ten years of life, illustrated in Fig. 125.

There is a theory put forward that the incidence of one zymotic predisposes to the occurrence of another. At one time the favourite idea was that attacks predisposed to tuberculosis. Save in the debilitated condition of convalescence, there is probably little in it, although scarlatina and diphtheria tend to vary together. It will be more applicable to town than rural conditions.

The association of measles and whooping-cough means that these two diseases are very prevalent at early ages, and the fortuitous occurrence of both will be seen on many occasions. Measles is said to occur twice as often before whooping-cough as the reverse, but it might also be noted that the cases of measles are also in the same ratio of frequency, and that this result is to be expected.

In a Battersea school the large number of sore throats of a comparatively slight nature, among which cases of scarlatina began to crop up, suggested that these were abortive scarlatina. Enquiries many years later on affected schools and control schools shew that such outbreaks may be due to micrococcus catarrhalis, and quite unassociated with the hæmolytic streptococci which are found with

scarlatina. So that even here, what was apparently a close association must be regarded as a chance occurrence (*L.C.C. Report*, 1920. 38).

The risk from exposure to infection is the main determining cause of zymotic diseases in those who are susceptible. An examination of the Registrar-General's mortality tables shews that for school ages 5–10, 10–15, the mortality of girls exposed to infection from contact with the sick in their homes has diminished as they went out of these homes into schools, and that death-rates are approximating more to those of the boys. There is one exception, and that is smallpox. The introduction of smallpox to the family, before Education Acts were universal, seems to have been mostly by males,

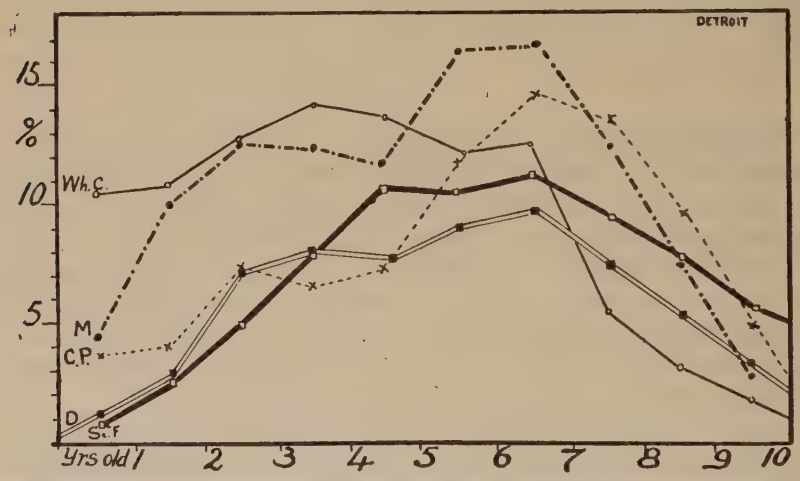


FIG. 125.—PROPORTIONS AT EACH AGE SUFFERING FROM THE VARIOUS ZYMOTICS (DETROIT RECORDS).

and there being time for vaccination, females were in some measure protected, and their death-rates lower; now, being equally at risk, they also become more equal in death-rates with the boys (*Journ. Roy. Stat. Soc.*, 1897. 623).

The question of school attendance as a factor in the dissemination of disease will be better understood if the detailed facts of the separate diseases are taken first.

WHOOPING-COUGH.

The school doctor, examining children above the infant stage, regards whooping-cough rather lightly. So far as school goes it is trivial. Yet it is one of the major diseases, one of the "Captains of Death."

In the first two years of life it accounts for nearly five times as

many deaths as scarlatina and diphtheria together. Both in England and America 97 per cent. of its fatalities are before 5 years of age. Still, the disease as a serious factor is largely beyond the ken of the school doctor, unless he has also some acquaintance with general practice. The absence of any congenital passive immunity makes it take a heavy tax of sucklings. Girls suffer more than boys, possibly through household exposure being more prolonged in their case ; more of them also die.

It is a difficult disease to handle, as the period of infectivity is early. By the time the diagnostic whoop comes, danger to others has almost gone. The Detroit Pertussis Clinics say that nine out of ten liable, being exposed, contract the disease. It is a sprayed infection, but there are also carriers, and it may be conveyed by soiled linen or the hands of a child's attendant.

The child exposed to infection may be taken to remain free from infectivity for the best part of a week. Illness begins to shew with some dry cough about the end of a week. The cough is often, at first, irritable at night. Somewhere about the third week the character of the cough changes, vomiting may occur, and then inspiratory dyspnœa. Early diagnosis may be difficult. Meyer (*Lancet*, 1916. ii. 1063) cultivated the bacillus by direct inoculation, exposing Petri dishes with a suitable gelatin, potato, and blood medium, about 4 in. in front of a coughing child. He obtained the Bordet Gengou bacillus in nearly every case for about two weeks of the cough.

Dr. L. W. Smith and his eight co-workers considered infectivity almost limited to catarrhal stages, as no cultures of the bacillus pertussis could be obtained after the second week of whooping, which is approximately the fourth week of the disease (*J.A.M.A.*, July 1925).

Whooping-cough diagnosis, for useful exclusion, is impossible in school. If the disease is prevalent, a child who becomes peevish and obviously ailing, with possibly some slight fever and a little cough, should be sent home. The unfortunate attendance fetish will, however, hinder this action. When the child begins to cough spasmodically, if it gets flushed in the face, or vomits, or has a nose-bleed, it will probably be excluded by teacher or nurse, but then the chance of evil to others is nearly over.

A record of 1000 cases of pertussis attending Great Ormond Street Hospital in 1922, shewing the age distribution, may be read in two ways—either that school attendances from 5 to 6 cause a rapid diffusion, increasing the numbers at that age perhaps 25 per cent., or that the pre-school ages of 2 to 5 are rather neglected for hospital treatment, which is equally likely (*B.M.J.*, 1922. i. 713).

The whooping inspiration begins in the third week, and this will probably last a full month. If accompanied by vomiting, the child

may suffer severely in nutrition. Although not infective, in later periods the child is best away from stress of school the whole time. The old remedy of change of air is to be recommended, especially if aided with plenty of milk and sunshine.

Ordinary schools are negligible in this disorder, but nevertheless an intensive study of the disease, the complete following out of a cycle, such as we did for measles in London in the early days of school work, has become a necessity. The future management of nursery schools is involved, as the most important prophylaxis for the pre-school child in towns will be that of whooping-cough. Its mode of spread in the family, the fact that there is no sucklings immunity, but that an attack confers permanent protection, indicate the importance of such an enquiry. The means of prevention exists but has yet to be found. Meanwhile none of the claims for prophylactic vaccines, curative sera, or radio therapy have been justified (1925).

Measles.

Measles is a scourge of infant life, so universal in occurrence yet so intermittent, that an exact numerical picture of its distribution in a community at any one time will be rarely true in a month or two.

The L.C.C. reports for 1896, "Measles death-rate (0·82) higher than any year since 1864, and higher than any European city save St. Petersburg," and again in 1900: "Rate 0·43, lower than most towns," make comparisons which are nonsensical. For any averages or comparisons considerable periods have to be considered. Districts away from highways of civilization may be swept once in a couple of generations. Remote Highland glens send out youths to become soldiers or policemen, and frequently to contract violent measles ere they have been many weeks in the city.

Contingents of country recruits, both in England and America, suffered heavily from measles. One Highland camp in the South Midlands was reported to have had a case mortality of 10 per cent. in the first winter of the War, with many cases.

When measles comes on virgin soil, as in Fiji in 1875, it is severe. There it caused 25 per cent. mortality of the inhabitants. As late as 1911 in Rotumá, 260 miles from Fiji, after eighty years of freedom, an outbreak caused a death-rate of 246·5 per mille among the population of 1983 souls.

The disease seems to have been milder formerly. Watt, writing of it in 1813, remarks that now it has become ten times as fatal, although it could hardly be more common than it used to be. The 1846 outbreak in Faroe, where the period of incubation was first determined, had a fatality of only 1·6 per cent. among the 6000 cases, probably because there all cases were known.

Case mortality is difficult to ascertain. Even when there has been notification over a long period many cases are missed. Case mortality at Aberdeen was 3·3 per cent., Edinburgh 3·5 per cent., St. Helens 3·3. Of the 8167 cases Butler followed out at Willesden, the mortality was only 1·6 per cent. On the other hand, Paterson (1909) in St. Helens, where there is notification under a local Act, had 41 deaths among the notified cases, but the Registrar-General's return gave 170 deaths from measles in the period.

Assuming 3·3 per cent. as about the ratio, a diagram of measles cases for London was reconstructed. Cases were presumably three

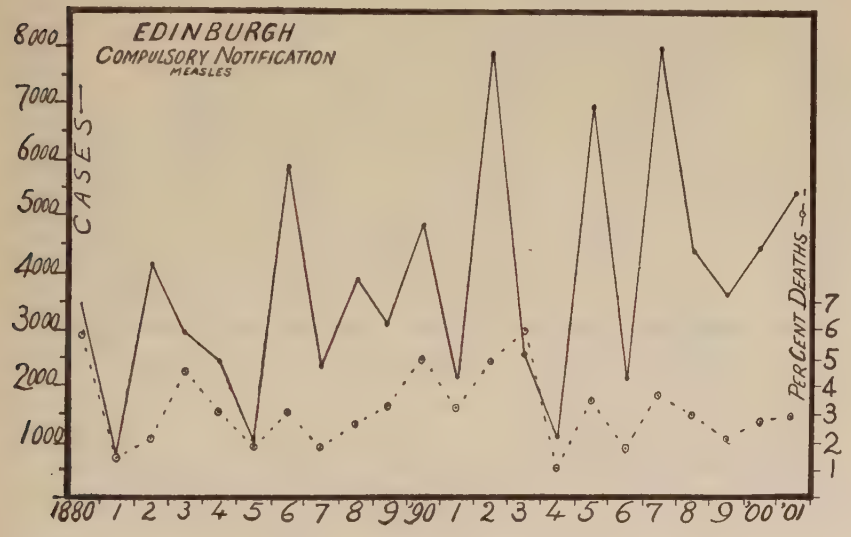


FIG. 126.—EDINBURGH RECORDS DURING THE PERIOD OF COMPULSORY MEASLES NOTIFICATION.

times as many as the school returns gave (*L.C.C. Report Med. Off. Educ.*, 1911. 131).

During the period in which Edinburgh had notification, the annual numbers of cases, and the percentage case mortalities, are shewn in Fig. 126.

Case mortality is not closely related to case prevalence, and often appears greatest when the epidemic is decreasing. Notifications of cases of the disease may give fallacious returns, but mortality figures are beyond dispute, although they only give minimal values. The crude mortality rates annually for London for the past forty years shew that even measles is declining.

The vertical dotted line in Fig. 127 marks the beginning of our measles enquiry and the scientific method of handling outbreaks, as compared with the old method of school closure, but

the drop had already begun and cannot be attributed to our school-work.

Most statements apply to comparatively urbanized districts where measles is common. Few children escape, and, like whooping-cough, its severity is in the earliest years.

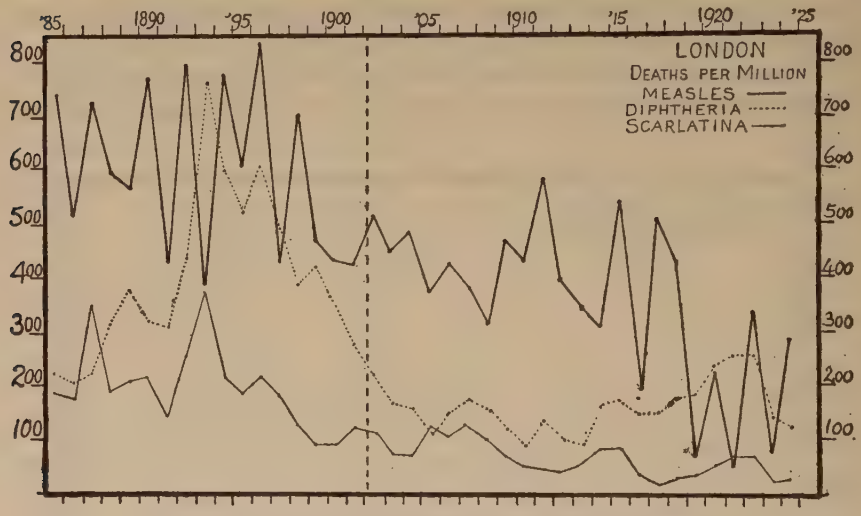


FIG. 127.—LONDON RECORDS FOR FORTY YEARS.

The Aberdeen figures of over 40,000 cases give the following typical urban distribution, although the first half-year escapes—

TABLE 89.

Age ..	0–	1–	2–	3–	4–	5–	6–	7–	8–
Attack rate per 1000 at age	44	86	86	79	75	86	75	47	21
Fatality per 100 cases	13·9	10·0	3·4	1·6	0·9	0·7	0·5	0·5	0·4

Immunity.—Both active and passive forms of immunity to measles are demonstrable. The active immunity appears only conferred by actual attacks of the disease, and then is very persistent. Second attacks are almost unknown. Probably the majority of recorded second attacks are false diagnoses. Physicians of great experience like Cautley, Brownlee, or Goodall have either only seen single cases or not seen a recurrent case. Every such case the writer investigated has broken down as a second attack of measles.

Wilson, going over the Aberdeen records, found second attacks

recorded in 9·6 per thousand under 5, 43·8 per thousand at school ages 5 to 15, and 98·0 per thousand over 15.

Second attacks in school children being certainly less than 1 per cent., may be left out of account.

The new-born child, whether breast or bottle fed, receives a congenital passive immunity from its mother if herself protected by previous attack. This persists for four or five months, slowly disappearing in another month or two. Lasting immunity is conferred by an attack of the disease. In towns, 90 per cent. of the community are aware of having an attack at some time in their lives. The child of 2 or 3 months old in a family where measles occurs

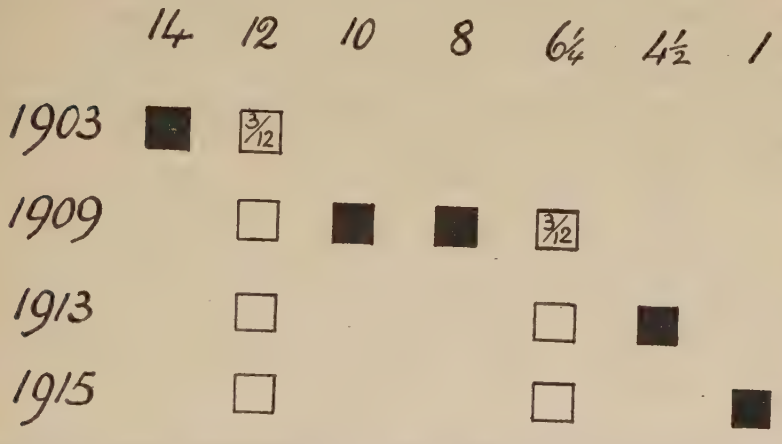


FIG. 128.—FOUR OUTBREAKS OF MEASLES IN A FAMILY, SHEWING SUBSEQUENT IMMUNITY OF EXPOSED BABIES.

probably escapes not only then but for the rest of its days (Herrman, *Trans. Am. Ped. Soc.*, 1926. 278).

Infectivity.—It is strange that with this pronounced effect there is not evident a greater salting of the child population towards measles, from repeated exposure to minimal doses. The high infectivity of measles suggests that the protection acquired is only sufficient in the majority of children who escape for three or four years, not for complete protection, but for trivial, mitigated forms which become common among them. Everywhere there is a percentage of mild but infective cases which are never noticed beyond the home. Children of a superior social class who do not receive this protection, slight though it may be, generally take measles at school and often suffer severely.

The measles experience of unsalted War recruits was a disastrous mortality. The measles mortality of the large Public Schools is considerable.

The infectivity of measles is high, hence the frequency with

which an infecting dose is encountered by even the partially protected. Its range of infection is narrow, and duration short lived. Spread of disease at any time will depend on the increased proportion of immune persons preventing direct infection. Where three-quarters are immune it does not readily spread. They also act by widening the range, diminishing the risk of others coming within striking distance. The chief factors, then, are time since the last considerable prevalence of measles, and local density of population. Different sections of the population run different risks. After a violent epidemic in London during the Winter and Spring of 1910–11, by May 1911 immunity had been conferred on 81·6 per cent. of the pupils of infant schools, varying from 70·1 in Hampstead to 86·7 in Islington. So far as cases can be controlled, measles should be postponed till after 6 years of age, and got over by 8 ; nothing is gained by delay.

The relative variation in age groups remains steady over a series of years. The percentages of deaths occurring in each age group in London were as follows—

Table 90.

	Number of Deaths.	0–	1–	2–	3–	4–	5–	10–
1890–9	26,954	20·7	40·7	17·4	9·5	5·5	4·9	0·2
1900–9	19,862	22·4	42·6	17·0	8·7	5·1	4·1	0·15
1909–18	18,443	20·3	42·4	17·5	8·6	5·1	5·4	0·17

Summing the six heaviest and six lightest years together, they did not vary as much as these three decennia, so that the ratio of age distribution is fairly constant, and apparently school efforts produce no effect upon it. The solid fact is apparent that total deaths are 70 per cent. less in the last decennium. School efforts may be one cause, for it was from 1902 that measles control was thoroughly attempted, but it is just as probable that the spread of education and better home care are the true causes.

The distribution is much affected by density. For 1891–1900 at different age groups in England and Wales, the death-rate per million living was as given in Table 91.

The postponement of time of attack in rural counties as shewn by higher death-rates of older ages also suggests time for a considerable acquirement of partial immunity among younger children. In Dublin, among 104,000 of professional and middle class, there were 23 deaths from measles; whilst among 154,000 of general

service class, 223 occurred (*Lancet*, 1909. ii. 160), about seven times the proportion.

Brownlee attempted to use the Periodogram to analyse measles epidemics (1917) and has applied this to various large towns (*B.M.J.*, 1919. i. 246). He finds several periods, but the results as yet appear indefinite and without practical application. The explanations involve a considerable number of environmental factors as well as the possibility of cyclic changes in the organisms. "None of the ordinary solutions seem to cover the statistical evidence."

The Natural History of Measles.—The acquirement of much immunity from small repeated doses is unlikely in measles, an infective dose being easily met, and incubation going on silently. For elementary school purposes there is an interregnum of about nine days before catarrh and *malaise* appear. We have taken eight days as the period of safety, but it is possible that for absolute safety six or seven would be the limit. During this period the

Table 91.

ENGLAND AND WALES. PERSONS. MEASLES,

Ages	0–	5–	10–	15–	Total.
Urban counties ..	4067	242	11	5	512
Rural counties ..	1573	165	28	10	212

disease is incubating. In a residential school it might be useful to be watching for a possible case. The plan of a typical measles attack is set out in Fig. 129, but a range of thirty to forty hours is common in the course of the disease, and in partly protected children the incubation period may be delayed up to three or four more days.

Early Signs.—There is a polynuclear leucocytosis which reaches its maximum about the 6th day and then changes over into a definite leucopenia with diminished eosinophiles and lymphocytes by the time of the rash. A loss of weight, beginning towards the end of the first week after exposure, is frequently stated as Meunier's sign.

The most important, however, is an isolated evening rise of temperature 101° to 104° F. somewhere about the 7th to 9th day, with a remission for one or two days ere the regular fever begins, and increase till the rash appears. This is, perhaps, the first definite symptom of active infection. The beginning of the measles catarrh most common, according to Brownlee, is œdema of the palpebral conjunctiva of the lower lids. The child then is infec-

tious. A short dry cough is common as the catarrh sets in, about the 8th or 9th day. After this with the *malaise* there may be some 5 to 10 per cent. shew transient, patchy, prodromal rashes, and sometimes a nose-bleed before the time the true rash begins.

Tonsillar spots may rarely be seen as early as the 7th day. As they are found often two or three days before Koplik spots, they may be valuable in institutions or homes in selecting children for isolation, although possibly no catarrh has appeared.

Koplik's spots can be found about the 11th day, and the measles rash on the face or buttocks at the 12th to 14th day. Koplik regards the spots as coming almost at once after the initial fever, and being demonstrable four or five days before the rash. The

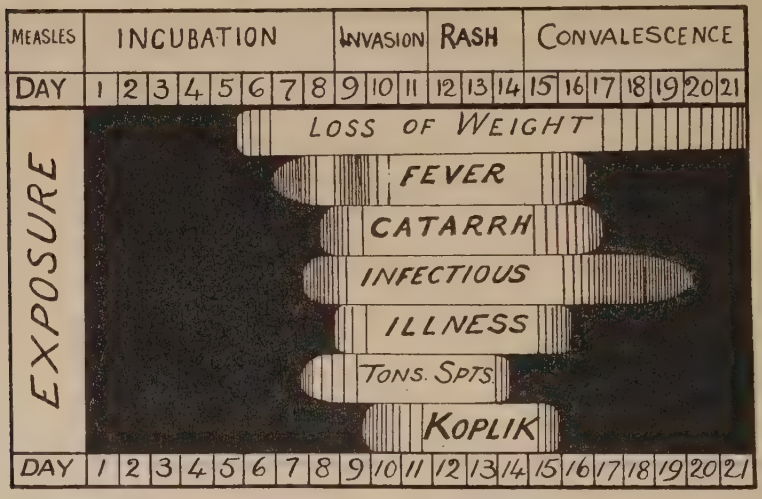


Fig. 129.—CALENDAR OF EVENTS IN AVERAGE MEASLES CASE.

Koplik spot is a vesicular exanthem on the mucous membrane, best seen inside the cheek, the surface shewing a parakeratosis. It is a round, rose spot with a pale centre, and described as looking like a fine tubercle ; sometimes the reddening of the base is not evident. Seen in a good light, the surface is a little raised and matt. They are often grouped, and are frequent opposite the lower molars.

They are a certain sign, but care must be taken not to mistake some of the small normal glands for the spots. For differential diagnosis they are of the greatest value. For ordinary school purposes they are of scanty use.

The daughter of one of my colleagues was medically examined in the routine at a secondary school, and although complaining of *malaise*, an abundant Koplik rash was missed, till she went home. At Christ's Hospital Schools Dr. Friend has, by a morning parade search for Koplik's sign, frequently removed boys at an early stage.

It is doubtful, however, whether the Koplik spots help to remove sufferers before some infective damage is done.

The measles rash presents little difficulty in elementary school-work. In its fine form it may be mistaken for rubella or scarlatina, although a bluish tinge is never seen in these. The coarse form looks like urticaria. Usually there is a suspicion of what it is, and the question of whether the child has already suffered may give the answer.

Former Practice.—Former school treatment of measles was very crude. In Bradford, in 1893, it was the rule to close a school when the attendance had dropped to half. By this time usually the epidemic had burned itself out, leaving only 20 per cent. susceptibles. Its cessation on school closure was taken as a success. The last of such " successes " is recorded in *Lancet*, 1912. i. 204. Where an epidemic numbering 853 cases had 638 fail whilst at school, 140 in the fortnight after closure and only 75 later. The margin of safety had been reached before the closure, which was without effect on the outbreak. Schools were supposed to be great disseminators of disease, but little was known of the part they played in the natural history of the disease. For myself, the spread of an attack in an isolated village school being followed day by day, and then the violent outbreak of many cases in another school during its first ten days after the Christmas holidays being noted, served to establish the mode of spread, and action of holidays.

School evidently played a very secondary part in the diffusion of measles in a place like Bradford. The majority of the cases never came in contact with a doctor. A scheme was devised for the free diagnosis of cases of illness in school children by medical men, notifications being paid for by the municipality, but it never came to life. It could easily be done by nurses, with a little organizing, and well advertising.

The Woolwich Enquiry.—An enquiry was planned at Woolwich in 1902, to last for five years, the utmost possible school closure being followed in the eastern half of the Borough, and class closure only in the western half. This class closure was very costly in attendance, and soon modified to keeping a measles record of each child in the school register. On occurrence of a case, non-immune contacts were excluded from the 9th to 14th day after the risk of infection. In that time the affected ones fell with the disease whilst out of school. The detection of the first case was seen to be the problem, but often the first case remains unknown. It is here that the school nurse as attendance officer could also be a sufficient diagnostician as to whether the doctor is wanted, or exclusion needed.

After several years Dr. Davies was able to report that whilst more cases were notified in the non-closure districts, closure made no

appreciable effect on the age incidence, and that the death-rates in both districts were about equal. He concluded his report in 1906 by the statement : " There is no doubt that in a large proportion of cases the infection of measles is contracted at school, and brought by children attending school to the younger members of the family not attending, among whom measles is so fatal. Now, obviously, if the age of school attendance were raised by one or two years the number of young children, none of whom attended school, would be increased in proportion, and a large number of young children who are now exposed to the risk of infection would be comparatively safe."

Temporarily accepting this statement as correct, and it is still the current doctrine, although I have always disagreed with it, certain results soon followed. It was unnecessary to close school-rooms other than infant departments, and there was no reason for children to stay away from these schools on account of measles at home. This was much misunderstood. Half a dozen years later we find the comment, " It is incredible that any body of intelligent authorities should countenance a proceeding so fraught with danger to the entire community " (*Lancet*, 1912. ii. 249). It is now everywhere in England the usual practice. These elder children need not be further considered here.

Reporting finally on the Woolwich scheme : " Our experience shews the usual official sanitary idea of results in measles prevention by school or class closure is mere imagination, and that closure applied in the only successful manner, at the occurrence of a first case, postpones measles for such a short time that the interference with school-work, except under special conditions, is hardly justified, and that for any effective results trained teachers capable of detecting the first case of measles are an absolute necessity " (*L.C.C. M.O. Ed.*, 1907. 45).

Young children are the centre of the problem. Davies hinted at later school entry, and that was the favourite solution of Medical Officers of Health. There seemed something in it. Whilst prevalence is noted (*L.C.C.*, 1897) among pre-school children, they are later supposed to be infected from school. School, as Dr. Thomas said, may be looked on as a heap of inflammable material wanting but a spark to set it going. Everyone knows such cases. Dr. Rose of Aberdeen (1912) reports a boy who returned to an infant class-room after a rash and slight illness. Two weeks after that date, 57 others in the same class developed measles, and in two weeks more the remainder of the unprotected were laid down. This one boy had infected the first 57 directly. He might have done the same outside school.

School and Measles.—The idea that school plays so great a part comes from such accidents, which also happen in other diseases

where the school is quite trivial in effects. Sometimes when an epidemic prevails a school will stand isolated for long.

At Bonninghardt, a small German village, scattered over a tree-clad hill with well-separated houses of Catholics and Protestants, measles appeared in two classes of the Catholic school, which had 143 children in them, and 139 children went down. In the Protestant school, with a class of 112 infants, 7 minutes away, no case occurred. Their turn came later. The same occurrence happened in another German village of 2000 inhabitants. Eighty per cent. of the Catholic children, and scarcely any others, were affected (*Zeit. f. Schul.*, 1892. 282, and 1894. 426).

In England the restriction of measles to single school-rooms is often referred to, but here probably the real reason is that in other rooms most children are immune. Yet, in hospital, measles infection remains in one room. The men who carefully work out epidemics nearly all give some internal evidence in their writings that they are not fully satisfied with school, as the *fons et origo* of epidemic spread.

Paterson, in St. Helens (1909), remarks that the epidemic travelled by personal contact from street to street. He applied our London methods, and notes that one school stood isolated in the midst of an infected district for weeks, till fifteen cases came simultaneously. A typical case he describes is one poor school that had daily visits for routine examination, and small batches excluded. As time went on these became more and more frequent and less regular, "shewing that the infection was entering the school from several sources."

Dr. Angus (Leeds 1916) notes, "a surprising number of cases were found in households with only one child, even when that child is below school age." In two-thirds of the homes the affected child was the only susceptible, whether an only child or not, any other children having already had the disease. "Of the remaining third, 75 per cent. had only one other susceptible child in the house, and this child invariably got infected."

Picken investigated the Renfrewshire cases (*B.M.J.*, 1915. ii. 429). He found the fall in two decennia in case rate 7·6 per cent., and in case mortality 32 per cent. He thinks, "It seems as if some factor had come into play, tending to reduce fatality more than incidence of disease."

Sharp, in Barnsley in 1918, found two-thirds of the houses were infected by single cases, and in 45 per cent. no secondary case. Nearly 60 per cent. were under school age. The four-room house, closely packed, the chosen homes of young people, contributed 70 per cent. of infected houses. In the same year Dr. Atkins of Wombwell says the outbreak had little to do with school attendance. The epidemic gained ground in the Summer holidays.

Dr. D'Ewart narrates how two Salford schools, owing to war exigencies, had to use the same rooms and desks, mornings and afternoons respectively. The children came from different districts, and whilst one school had much measles the other had none, so that school infection, *qua* buildings and material, was excluded.

Dr. J. W. Fraser of Hull regarded measles as spread by other means than the schools, and in the discussion (*Journ. Roy. San. Inst.*, 1912. 97) L. Parkes agreed that measles was really a disease of the home, and epidemics began in the home.

The weight of Brownlee's mathematics applied to the Aberdeen figures, by assuming a cause and constructing a distribution, assumes infection at school by the eldest, and shews that the distribution will correspond to that found. He concludes that "it may be presumed that, in the majority of cases, children under 5 years of age are infected by the elder children who acquire the infection in school."

This statement is probably quite true, save for the last two words. The elder children may bring it into the home, but they can acquire it anywhere, as their orbit extends beyond the home. All that this calculation does is to shew the school is not excluded.

Returning to Dr. Davies's solution that the age of entry should be raised, the suggestion has been made that in epidemics all children under five should be excluded from school. This was put forward in the L.G.B. memorandum on measles in 1911. The reasonable argument is that thereby mortality might be reduced by postponement of attack, but this seems extremely doubtful, for by the time an epidemic is declared it is too late to be useful. At an early stage it might be of use in a country district, elsewhere it is in vain. The orbit of the five-year-old in towns will not be diminished by exclusion from school, rather will it be brought into more intimate contacts. In the social stratum which has measles before five, school will be found trivial as a disseminator. As Dr. Lemprière says, regarding non-immune public school boys, the control of measles is non-existent.

Dr. C. J. Thomas thinks (*School Hygiene*, 1913–15) "the history of measles epidemics proves that, given a sufficiently unprotected population, measles will spread whether there be schools or whether there be none." He did not suppose a postponement of more than six months could be got. Measles recurs again and again in any class with 40 per cent. unprotected. In Scotland, where the age of school is a year older than in England, the mortality figures are greater. The discussion on measles reported in *School Hygiene*, 1913. 131, is very comprehensive.

In spite of the conclusion reached through my first twelve months' work of a limited but intensive nature on measles in Bradford, that school is not the main agent in diffusion, it is the duty of a school

doctor to save the pupils themselves as far as possible from illness. Diffusion in school depends on proportions liable. Where many are unprotected, the charted cases form a large, smooth and short-lived wave; where there is considerable protection the epidemic is spread out irregularly into several crops.

A typical example is where a case was first absent on February 23rd. Nine days later, five children were absent, and on the following day two more, and it was then decided that closure was too late to be useful. It was subsequently found that 104 others were then infected, and they failed within the next fortnight. The outbreak ceased when ten more cases had occurred in the following week.

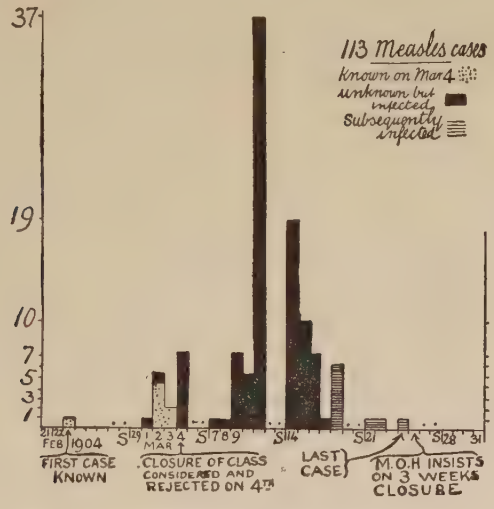


FIG. 130.—MEASLES OUTBREAK IN A HAMPSTEAD SCHOOL.

This was the end of the outbreak. The Sanitary Authority closed the school on the following day for three weeks, but there was no further case to occur. Closure at the very earliest opportunity we had, at its very best possibly would have avoided infection of ten out of the 113 cases.

The worst prevalence of measles in London from the beginning of the century was 1910–11. The mortality for this year was regularly exceeded in earlier years, for instance in 1890, 1892, 1894, 1896, and 1898. The Medical Officer of Health (Sir S. Murphy) wished to have the schools closed at the date starred in Fig. 131, but the Education Committee wisely kept them open, and the result shews, as usual, the outbreak had then done its worst.

Except in some remote country place, school closure is of no avail for the prevention of measles when cases have occurred in the school. A limited closure from the 9th to the 14th day might

catch the first crop. Exclusion of individual or unprotected children is the best school measure. The Birmingham method of sending notice to parents of unprotected children to keep them at home if there is any appearance of illness is good health propaganda, and worth extensive trial.

The machinery of infection is close personal contact. Probably it is a sprayed infection of short range. The 9 sq. ft. class-room, especially with warm, moist air, is harmful to infants in respect

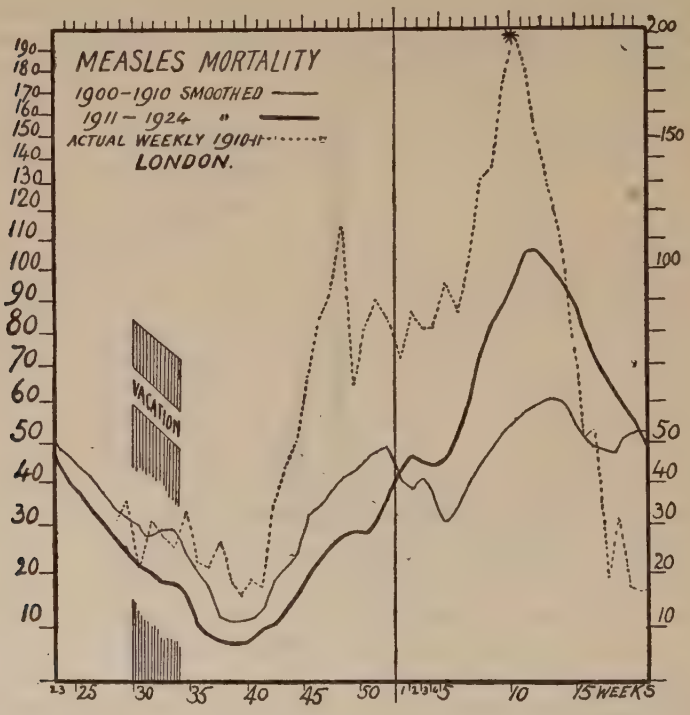


Fig. 131.

of any likely infection of measles. A 12 sq. ft. requirement ought to diminish any school risks of infection, as Dudley has shewn, by between 50 and 60 per cent.

Salting of children might be quite feasible given plenty of space and not allowing more than a certain proportion of unprotected children in nursery schools.

Future attack on measles will lie with nursery schools having plenty of space and open air, salting the children so that they only get mild attacks, and with good nursing and care of cases when they occur. Measles can be made an argument for nursery schools rather than against them. Spacing out and dilution by immunes is exemplified by the experience of the Jews' Free School. Here,

working on the "vertical system," the youngster has an older one looking after it. It is the natural system. The result is, that with more infants there is less measles than in any other school.

Munson's experience with spacing out American recruits and reducing measles incidence to one-tenth illustrates this (*Lancet*, December 1917). Good ventilation is one of the adjuncts of school prophylaxis. Space is wanted.

Notification.—Any system of compulsory notification has little public advantage. It is costly and achieves nothing. It is not in time to catch cases ere infective. It cannot secure isolation. In most cases isolation in the homes is impossible. With the explosions that occur hospital isolation cannot be got. It is of little use for treatment, as half the cases never see a doctor, or require treatment, and by all experience there is such a leakage that even purely for statistics it is unreliable.

Serious cases of young children die of suffocative measles catarrh towards the end of the first week; indeed, a quarter of the deaths are in the first six days. It is only very early free diagnosis, and a nurse or health visitor on the spot at once, that is likely to make any impression on the death-rate. Cases, too, of otitis leading to deafness, or superficial eye disorders resulting in permanent defect, might be helped by early advice. In London, during measles prevalence, nurses visit daily in the schools hunting possible cases, and school attendance officers are also watchful. If necessary, the local Medical Officer of Health has the house visited with a view to possible need of advice or nursing treatment.

The steady fall in the death-rates from measles in London is more likely due to educative action of school, than to an prophylaxis carried out through attendance regulations.

Measles mortality in recent years promises to fall below the rising diphtheria mortality, which last is not a credit to London's intelligence (1925).

Notification is not useful towards disinfection, which is unnecessary with measles. Although some Local Medical Officers of Health still carry out "stringent disinfection" *qua* measles, it is a waste of money. Its chief use is in securing nursing service in cases where the home conditions call for this help.

Conferred Immunity.—Measles may yet be controlled through the possibility of vaccine reactions similar to those which give control of diphtheria and scarlatina where used.

Reviewing Willesden cases in 1913, Butler concluded that immunity was the only protection, and that until a vaccine was produced there was little hope of better conditions.

A considerable amount of work as yet is without complete success in producing permanent active immunity. Herrman

attempted to immunize infants under 5 months old by swabbing their nasal mucous surface with secretion from infected children. A reaction at the normal time may represent aborted measles. Attempts to reinoculate them a year later failed (*Arch. of Ped.*, 1915. 503). This represents active permanent immunity. Injecting serum from convalescents (McNeal, *J.A.M.A.*, 1922. i. 340) immunized children. All serums after the 9th day seem to protect up to perhaps six months. This is a passive immunity.

Degkwitz, in Pfaundler's Klinik, used adult serum in large quantities. Zingher (*J.A.M.A.*, 1924. i. 1180) takes adults' or parents' serum, dries it *in vacuo*, keeps it in ampoules, and dissolves in normal saline for use. It retains its properties for six months. Sera should be pooled to get an average. It acts best before the 5th, but may modify to the 8th day. Complete passive immunity can be obtained. A temporary partial immunity, then abortive attack, probably gives a more permanent active immunization. Herrman's swabbing may be used, and next day a serum injection. Zingher finds double quantity of whole blood of immune near relative (parent, brother, sister) injected into gluteal muscle gives passive immunity of a month to six weeks. As suggested, if modified measles happens, all the better, as permanent active immunity results.

After years of work and thought on the subject, as seen in town life, one is bound to summarize in the declaration that all the school efforts are not worth the cost. All the isolation, exclusion, or disinfection possible does not postpone the incidence of measles in 10 per cent. of those liable by more than five or six months. School, in comparison with other conditions of urban life, is trivial in measles distribution. In thinly populated country districts restriction by school exclusions is still worth the cost and trouble, as there the orbits of the children are narrow and restricted except when they overlap in school attendance.

Diphtheria.

No child in Ohio need die of Diphtheria.
Official Report, 1924.

Formerly, in one's student days, the only disease that seemed to inspire fear was diphtheria, its apparent mortality was appalling. Now the history of the disease has shewn such a steady advance in scientific knowledge that we have a qualitative and quantitative knowledge of the facts, and power of control far beyond that for any other disease.

Weak and timid administration and popular ignorance still render that knowledge of little avail among us, either to save money or the lives of the community.

Bretonneau, in 1826, isolated the disease as an entity from a tangle of other complaints. Klebs (1883) separated the bacillus, and Loeffler (1884) shewed its power of infecting animals. Roux and Yersin (1889), Sidney Martin, Kitasato, and others unravelled its chemistry. O'Dwyer developed intubation for surgical relief. Von Behring (1890) prepared the curative antitoxic horse serum, which has enormously reduced the mortality, although not the case rate. He found (1912) that the passive immunity was unreliable on account of the dissociation of antibody, and that toxin mixed with antitoxin, whilst it took longer to protect, gave more permanent effects. Schick published his test for susceptibility in 1913, and with this as a guide, Park and Zingher have in the past ten years developed the toxin antitoxin method of active immunization, which justifies the heading of this section.

Diphtheria, as recognized formerly, was most pronounced in country districts, now it is mostly urban, and to the general practitioner seems more associated with better-class, suburban, newly built areas, not with poor-class schools. It is a winter disease.

This disease is the reaction to infection with the Klebs Loeffler bacillus diphtheriæ, which can be found in practically every case. The bacillus may be present and be isolated from the throat of some persons who are in perfect health. They are not suffering from any disease, and could not be notified as infectious, although Kirchner decided that they came under the Prussian law as " sick " (*Z.*, 1912. Sup.,198).

When infected by the bacillus, for which we will use the term K.L.B. (Klebs Loeffler bacillus), this produces toxins. The poisonous, necrotic effects of these on the nerve centres and muscular tissues are shewn by onset of pareses late in the disease. The most common post-diphtheritic symptoms in school children are temporary conditions such as weakness of the accommodation from ciliary pareses ; weakness of the soft palate, which may cause a difficulty in swallowing, or nasal tones in the speech. These symptoms occasionally indicate a diphtheritic infection where the attack itself has been overlooked or attributed to some other cause. In rare cases long lasting palsy of other muscles may be slowly recovered ; for instance, a teacher 25 years of age was practically crippled by extensive paralysis, but after three years' treatment made a good recovery and resumed work.

Post-diphtheritic heart weakness is common and may have to be guarded against for months, especially in such matters as violent physical exercise. On infection with the bacillus any reaction will be suppressed if there is sufficient defensive antitoxin naturally present in the blood to neutralize toxins produced by the bacilli, although these last may continue to exist in a saprophytic way without infecting the system.

There is thus possible two classes of persons affected by the bacillus :

(*a*) The otherwise healthy individual, a carrier of bacilli ;
(*b*) The individual diseased from being infected by the bacilli and their products.

There may be a light tonsillar infection or more extensive pharyngeal inflammation, or the serious nasal and laryngeal extensions. Caiger (*Lancet*, 1924. ii. 53) shewed that clinical and laboratory diagnosis agreed in 97·5 per cent. of cases. In school the condition seen is likely to be tonsillar infection, or more chronic nasal forms. Rarer forms occur ; for instance, a grey diphtheritic membrane as big as a five-shilling piece has been seen by the writer spread over an ulcer on the external surface of the cheek of a schoolgirl. A five-year-old boy with chicken-pox infected the vesicles with diphtheria from nasal secretion by scratching, and died (*J.A.M.A.*, 1925. i. 1983).

The diphtheritic patch seen in the throat is a white or grey raised deposit on the mucous membrane, and not ulcerated or excavated. It is usually a single patch. The small yellow patches on the tonsil, or plugs, in a swollen follicular tonsillitis differ from diphtheria. The only condition likely to be mistaken would be the equally serious Vincent's Angina. An outbreak of this where twenty cases occurred in a residential institution is recorded (*Med. Off. Ed. L.C.C.* 1908. 63).

Children are seen in school when an attack of nasal diphtheria remains infective. Many observers think this variety more infective than the throat condition, and multiple infections are commoner in the homes of children with such nasal trouble.

Sometimes only one nostril is infected, and probably its posterior segment. The child is likely to be anæmic from the toxic result of the diphtheria ; and the nostrils swollen, but not reddened ; sometimes with a thin discharge which rarely is streaked with blood. This condition may be seen as the result of infection during some other disease as scarlatina or measles. A boy supposed from his frequent colds to be the subject of chronic bronchitis really had persistent nasal diphtheria. This kind of case is similar to the nursling who itself having considerable immunity merely becomes infected, there is an ichorous nasal discharge with K.L.B., but no illness of any import, although the nursling may thus be a dangerous carrier.

Bacteriological Examination.—The London rule has been to take separate swabs of throat and nose, making streak cultures at once on solid blood serum sloped in a tube.

The test material is removed by a wire loop, which can be sterilized in a flame. Care is taken to avoid provoking sneezing,

by any contact with the front of the nostrils. The tube is then labelled with date, name, and examiner's initials, and sent to the laboratory. The tube is incubated at about 37° C., and examined at the end of eighteen hours. K.L.B. colonies shew as minute, opaque, whitish circular discs, darker in the centre by transmitted light. Material from a colony is removed by the loop, spread as a film on a slide, dried and stained. A general stain is first used such as Loeffler's methylene blue. A stain which keeps well and more frequently used is toluidin blue 0·1 g., with glacial acetic acid 0·5 c.c., in 100 c.c. of distilled water. The fixed film has a drop of stain placed on it, the excess of stain taken up by pressure of a filter-paper. Examination after about a minute shews purple polar granules, with the bodies of the bacilli faintly blue. The stain is deeper for the K.L.B. than for most similar organisms. In any doubtful case Gram's method should be used, or a second film put through Neisser's stain, which is a trustworthy, confirmatory

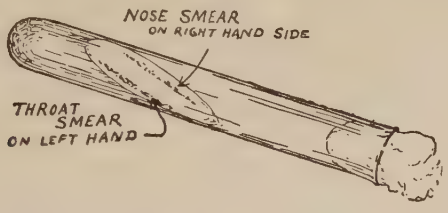


FIG. 132.—USEFUL ARRANGEMENT OF DIPHTHERIA CULTURES.

method, and brings out the polar granules, sometimes doubtful with the methylene blue. Two solutions are used : (*a*) methylene blue 1, absolute alcohol 50, glacial acetic acid 50, and distilled water to 1000 ; (*b*) crystal violet 1, absolute alcohol 10, distilled water 300. The stain used for 3 or 4 seconds is 2 parts of *a* to 1 of *b*. The film is then momentarily washed, counter stained for 4 or 5 seconds with 0·3 per cent. aqueous chrysoidin, then dried and examined. It gives the polar granules deep blue, the rest of the bacillus brown.

The morphological type of the K.L.B. was of considerable importance, as differentiating it from various diphtheroid organisms of which the chief was Hoffmann's short, thick bacillus. Occasionally the K.L.B. varied in its form, sometimes short, sometimes with clubbed forms, varying from 3 μ to 5 μ in length and not always the long, slender bacillus with several polar granules, which was looked for. The K.L.B. shews groups in a kind of Chinese letter pattern as fairly characteristic. Whilst these characters are common, they are not invariable, and additional fermentation tests which shew many varieties of bacilli are also used. Fermentation of glucose, maltose, and dextrin, with no change in saccharose is a

valuable indication of virulence; but animal tests are the only final solution. The Xerosis bacillus may be almost indistinguishable from K.L.B., save that it does not give an acid reaction with glucose bouillon.

The clinical necessity of striving for certainty from these examinations has now been removed by the Schick test. Experience has shewn that diphtheria cannot be controlled effectively by culture of swabbings, and use of antitoxin, as treatment is not always early enough, so that this additional method was needed.

In 1913 Bela Schick published his skin reaction test for susceptibility to diphtheria (*Munch. Med. Woch.*, 1913. lx. 2608). Whilst many people are immune to diphtheria, those who are susceptible will react to a minute dose of the toxin. This toxin is prepared by growing K.L.B. in bouillon, filtering, and sterilizing the filtrate with carbolic acid. An amount corresponding to one-fiftieth of the minimum lethal dose for a 250 g. guinea-pig will give a positive reaction in sensitive persons. It has to be injected intradermally through a very fine needle. The bore of the needle should be visible under the skin, or it is too deep. A whitened wheal will appear, with induration and redness around. It extends about 5 by 2 mm., and will last for several days. With such a reaction a patient would be susceptible to diphtheria infection. If no reaction occurs, this is due to the presence of antitoxin in the blood. The amount necessary is about one-thirtieth of a unit of antitoxin to a cubic centimetre of blood, and with such an amount any systemic infection by diphtheria would be unlikely. Von Behring thought that as little as one-hundredth of a unit would suffice. This Schick test, then, serves to differentiate those who are immune to diphtheria from those likely to contract infection.

Reaction due to the toxin is either positive, as described, or, when immunity is present, negative—that is, there is no reaction. Some cases, after the first decade of life, become sensitive to the protein from the bodies of the broken up bacilli, and give a reaction, known as a pseudo-reaction, due to this cause alone. There is usually no induration, it is an urticarial response, which appears more quickly than the Schick reaction and fades in 24 to 48 hours, the other lasting several days.

This protein sensitiveness is detected by a toxin injection on the flexor aspect of the right forearm. A control injection of toxin solution which has been heated to 75° C. for 10 minutes, destroying the toxin but not the proteins, is also used. It is injected in a similar position to the first, but on the left arm. If this last, which contains no diphtheria toxin, is examined after 24 hours usually no reaction shews, but possibly there may be a pseudo-reaction. If there is no reaction on this left arm, then the right arm shews either a *positive Schick* or a *negative Schick*, indicating liability to infection

from want of sufficient antitoxin in the blood, or immunity from sufficient antitoxin being present to prevent symptoms. If there is a pseudo-reaction on the left arm, the right will also be affected by the proteins present, and this effect has to be discounted by examining the right arm on the fourth day when it may shew a positive Schick combined with the pseudo-reaction, as judged by the difference between the two arms, or it shews a negative Schick combined with the pseudo-reaction.

Pseudo-reactions alone, indicate sensitiveness to the proteins, but immunity to diphtheria. Combined positive reactions shew necessity for immunizing against diphtheria. The negative pseudo-reaction is rare in young children, occasional in older ones, and not uncommon in adults. If it is misread, and an immunizing injection is given, there may be a considerable reaction and *malaise*, solely from sensitiveness to the proteins ; a result which is unnecessary, as these cases are immune to diphtheria.

For clearness, only the distinct types of reaction have been discussed, but all kinds of intermediate reactions are possible, depending on the amount of individual immunity.

In actual practice, where large numbers are handled, two doctors and a nurse form a team. The records are kept by the teacher or an elder scholar. The nurse prepares arms, one doctor injects the toxin in the right arm. The second doctor injects the left arm with a similar amount of toxin which has been heated. From 120 to 150 children an hour are thus tested.

The toxin antitoxin generally used is diluted to give the requisite dose in 2 c.c.

The reliability of the results depend on a correctly standardized toxin being used.

The persons making the test must have skill and a good technique, as the injection has to be *intradermal*. They should also have had experience in reading and interpreting the later results of tests.

As diphtheria is a risk to about 70 per cent. of pre-school children, and to considerable numbers of country-school children, and as its death-rate runs to about 8 or 9 per cent. of all cases notified, it is advisable that all young children should be protected.

The distribution of non-immune cases, that is cases giving positive Schick reactions found by Park in New York schools, was (1922) in percentages,

0–3 Months.	3–6 Months.	6–12 Months.	1–2 Years.	2–3 Years.	3–5 Years.	5–10 Years.	10–20 Years.	20 + Years.
15	30	60	70	60	40	30	20	15

Robertson found much higher numbers in Leith (1925) : 77 per cent. positive Schick at ages 1 to 5 years, 64 per cent. at 5 to 10 years, and 52 per cent. at 10 to 15 years.

Park and Zingher insist that infants, especially in towns, acquire a considerable passive immunity from their mothers, but this fades in from three to six months. All infants should therefore be actively immunized at from 6 to 18 months old. Probably 80 per cent. of adults have immunity, but 80 per cent. of infants are wanting in it. On the other hand, 97 per cent. of the inhabitants of lonely Thursday Island gave positive Schick reactions (*Med. Journ. of Australia*, 1924. i. 111). Schick testing is unnecessary at pre-school ages as the children shew no reaction to immunizing at these ages, and scarcely any before 10 or 11 years old. Pseudo-reactions of proteid sensitiveness belong to older ages. Using the test does not interfere with school attendance, and in older children and adults saves unnecessary treatment of about half to two-thirds the number.

Protective Methods. Immediate Protection (Rapid).—In face of existing diphtheria or emergencies the Schick test shews those needing protection. They should have passive immunity conferred by the injection of antitoxic serum. Its protective effect is immediate and lasts for several weeks. It is a passive immunity which soon lapses. Even an attack of diphtheria does not always confer lasting active immunity.

The main public health purpose should be to confer permanent active immunity on the whole population. For any individual this means waiting a period of three to six months.

Later Permanent Protection (Slow).—The immunizing material is a standard toxin neutralized with antitoxin, so that 1 c.c. contains 400 units of neutralized toxin. It is injected subcutaneously at weekly intervals till three doses have been given. Zingher found that a single dose immunized about 80 per cent. of the cases. A second dose raised this to 90 per cent., and a third dose to about 97 per cent. No one can be taken as immunized till certainty has been obtained by finding a negative Schick when tested four to six months later.

Simpler Protective Method of Park.—For general school use, Dr. W. H. Park proposes elimination of the Schick test, saving time, material, and trouble. He at once injects a dose of toxin antitoxin subcutaneously. If there is no reaction the patient is immune, and nothing further is done. Most children shew a slight reaction like a modified Schick, but there is a somewhat larger area with the dose used, so that after a week's interval a second, and finally a third immunizing injection is given.

Toxin antitoxin must never be used as a therapeutic measure, in the face of existing disease or emergency. Sufficient antitoxic serum has the saving power which the slower toxin antitoxin lacks.

In an outbreak in school or institution it would be correct to ascertain with the Schick test who are " Schick negative " and who " swab positive for K.L.B." Those who are in both groups should

be isolated, as they are the group who include the carriers of virulent K.L.B.

In tens of thousands of cases Zingher has actively immunized he has seen no untoward case. Several fatalities were recorded elsewhere from toxin antitoxin having dissociated whilst frozen in cold storage (*J.A.M.A.*, 1924. i. 1675). These were thoroughly investigated (*Lancet*, 1924. i. 505). Formalinized toxin is now used, the so-called toxoid which, mixed with the necessary antitoxin, forms a stable solution. This can be frozen and thawed without danger.

Considerable numbers tested at St. Bartholomew's Hospital in 1922 shewed only 43 per cent. of the nurses and 34 per cent. of students with sufficient immunity to protect them against disease. In earlier years one can recall diphtheritic fatalities among students, nurses, and doctors. Two doctors of our London staff suffered serious and protracted illness through contracting the disease at work. All medical workers need assurance of protection.

The Schick testing has shewn that immunity is prevalent in crowded districts where there is opportunity for frequent subinfection. Niven, in 1907, reported the diphtheria death-rate in North Manchester between two and three times as great at school ages as the corresponding death-rates in Manchester Township. "This is the more remarkable as the Manchester Township is the poorest portion of the City, and on the whole has the poorest schools." Park has insisted that the better the social position and the greater the relative isolation of the individual the greater the want of immunity to diphtheria.

Carriers.—Thorne Thorne's criterion of sore throat as a test of diphtheria missed the healthy carrier. In early days of school work medical opinion was often opposed to the exclusion of carriers. Dr. Thomas narrates the case of a girl seen in school with the exudate, and giving culture K.L.B., whose father claimed compensation as he said three doctors had pronounced her healthy, and he produced a medical certificate for her good health. Unfortunately her sister developed diphtheria, whilst the girl herself became a chronic nasal case.

The persistence of K.L.B. in the throat after illness has been much studied. Sims Woodhead gives a table of 4765 patients under the M.A.B. The criterion of freedom was three negative swabs at weekly intervals.

Days when swabbed clear	Under — 30	— 60	— 100	— 150	— 200	Over 200 +
Numbers of patients	1293	2324	921	207	28	2

In particular convalescents such as R. C. (p. 711), the individual may be a carrier for years. Neisser had a case with nasal discharge which persisted virulent for eight years.

Soldiers observed in France, under equal and similar conditions (*B.M.J.*, 1920. i. 796), cleared up in a way which, plotted in times and numbers, shewed a logarithmic curve. This suggested that the causes of the disappearance were numerous small factors, that is equivalent to chance. Only four out of 500 persisted, and they had deep tonsillar infection.

Nasal carriers are sometimes very tedious. Eustace Hill traced several cases to a child who had had diphtheria five months previously, and still had K.L.B. in ear discharge. On her removal no further cases occurred. Diphtheroid organisms, and possibly K.L.B., are not rare in ear discharges, but virulence is uncommon. Forbes in his paper on the carrier (*Pub. Health*, 1923. 323) failed to find virulence among suspicious organisms in twenty-two cases of ear discharges. He gives about a dozen cases where other carriers, under observation over twelve months, were still virulent.

A form which lasts long and is often virulent, is a nidus deep in the crypts of the tonsil. Enucleation may put an end to the presence of the K.L.B. within a week of the healing of the wound.

These carriers generally give negative Schick reactions, and are therefore themselves immune. Anyone from whom K.L.B. can be cultured, whilst giving a positive Schick, may be regarded as incubating disease at the time. They are likely either to become ill, or slowly to have immunity established, the Schick altering to negative. Children with nasal diphtheria may miss acquiring immunity, and continue to give a negative Schick. The Schick test fails to detect the otherwise healthy carrier, who is immune, but may be distributing K.L.B. to his neighbours.

Children themselves immunized against diphtheria, although exposed, have not failed with diphtheria, but some have become virulent carriers. Carriers have also developed streptococcic tonsillitis with virulent K.L.B. present, but have not suffered from clinical diphtheria. Some of these cases may have been recorded as diphtheria after immunization.

The carrier of K.L.B. has been a safeguard of the community against epidemics by keeping up a useful amount of sub-infection, at the same time this individual is the commonest cause of any school class outbreaks, and the want of control of disease among the populace.

The numbers of otherwise healthy carriers are extremely variable with time, season and locality. Harrington, in Boston (*S.H. Congress*, Paris, 1910) at the opening of schools for Autumn, testing children who had not been exposed to diphtheria, found about 1 per cent. giving K.L.B. Park finds 4 to 5 per cent. in New York children (1922). Rose determined about 10 per cent. in Aberdeen (1914), and at Baltimore 18 per cent. (1920) were recorded.

The majority of children, especially if they have not been in

contact with clinical diphtheria, give cultures which are non-virulent. Where a child is a contact with an actual case, and gives positive cultures, they may be expected to be virulent. Eagleton found about a third of the characteristic cultures in London schools were virulent.

In our earlier work in London, all giving morphological K.L.B. were treated as dangerous, till a rather isolated school was found, in which many of the children were carriers. It was recognized that the district was generally protected, but the school was watched under the idea that a new-comer might become clinically infected. The first fresh child admitted, coming from a country district, unfortunately failed with very serious disease.

It is common experience that limited or even recurrent outbreaks of diphtheria are terminated on removing a carrier from the class or school. On the other hand, children with typical K.L.B. may be in schools or institutions without infecting others. Barnardo's Homes, at Ilford, in 1919–20 were found to have carriers —aural, pharyngeal, and nasal—in the various cottages. They did not appear infectious, and there was no clinical diphtheria.

It is doubtful whether diphtheria spreads much more in towns, where no systematic detection of carriers is carried out, than it does where active following up is maintained, there being so many carriers in the population escaping detection.

If all bacteriological carriers are neglected, save those known to have been in contact with diphtheria, probably little harm will result, although an occasional limited outbreak will occur. The only method of rendering the carrier unimportant is systematic immunizing of the child population, preferably in pre-school ages. Numerous cases with K.L.B. after a time cease to infect, and cultures from them at first virulent, when taken later, are non-virulent. Rarely a case is found where virulence seems intermittent. Guthrie (*Bull. J. H. Hosp.*, 1920. xxxi. 388) swabbed healthy throats with non-virulent strains, and they became carriers, but none shewed virulence. On the other hand, clinical diphtheria developed when virulent strains were used. There is no proof that non-virulent cases become virulent. Lewis (*Med. J. and Rec.*, N.Y., 1924. 129) thought that virulent nasal carriers gained their infection from avirulent cases, but he is perhaps the only supporter of the idea. O'Brien failed to convert the one variety to the other, and Eagleton failed to convert, or to protect against virulent by using avirulent injections.

There may be mixed strains and the virulent forms die off. Fraser and Duncan (*Lancet*, 1920, November 13th) note a girl of 12 a carrier, who had caused three outbreaks in three years, who was treated with vaccine, and two months later the K.L.B. were found non-virulent. She mixed with the others, and was allowed to sleep

with a sister who had no disease but was also found to have non-virulent K.L.B.

Virulent carriers occur in whom no contact with diphtheria is known; for instance, Guthrie at Boston in his 800 children found eleven with virulence in whom no contact with diphtheria was known for three years previously. Yet, if carriers are not contacts, risk is small.

In Detroit a vigorous effort was made (1921) to detect and isolate all school carriers. They continued their studies in a room by themselves, and had their throats swabbed twice daily with 5 per cent. mercurochrome solution. If the organisms persisted over a week they were treated as special cases. By the Summer of 1924 a further step was justified, and carriers not associated with diphtheria were returned to school, 97 to 49 schools. The contacts in their class-rooms and homes were over 1200, but there were only nine subsequent cases and at such a long interval that they could not be put down to the carriers.

Where the disease does not exist isolation of non-virulent carriers is waste of time, effort, and money, and causes hardship. In Minnesota (*J.A.M.A.*, 1924. ii. 1132) children and infants who are found to be carriers unassociated with a clinical case of diphtheria are permitted to return to the child welfare clinics, and so far there have been no injurious results.

Other methods have been used. Hewlett and Nankivell used endotoxin with little benefit. Brownlee used a diphtheria vaccine, and found it the best for the chronic carrier, after all throat applications had been in vain.

Neisser used Behring's serum, then Ehrlich's toxin unsuccessfully. Petruschky used dead cultures of the bacillus effectively in recent, but not in old cases.

Attempts have been made to get rid of the bacilli in carriers by endotoxins, serums, or toxin injections (Neisser 1902, Petruschky 1912, Hewlett 1912, Brownlee 1920, Pesch 1922), but all are more or less unsatisfactory. The crypts of the tonsils in one variety of carrier were demonstrated by Graham Smith to maintain bacilli beyond the reach of disinfectants. Tonsillar enucleation here is most successful (Pegler 1905, Sears 1919, Ballantyne 1917, Hubbard 1917, Kent-Hughes 1920, Brownlee 1920). Cases usually clear up in a couple of weeks. For ordinary routine this would be too serious, but for a chronic virulent carrier, if the seat of infection has not been determined elsewhere (nasal cases), it may be considered.

Cases of diphtheria often appear in scarlatina wards and vice versa, and children sent in with scarlatina return from hospital occasionally as diphtheria carriers. The increase of susceptibility to scarlatina during diphtheritic attacks has been confirmed by the Dick test (*Brit. J. Child. Dis.*, 1925, 193). There appears some

depression in immunity during severe illness ; Gladys Ward (*B.M.J.*, 1921. ii. 928) records that at the Edinburgh Children's Hospital acute cases of disease gave 67 per cent. positive Schick, whilst chronic cases gave only 28 per cent.

School Accessories.—Dr. Heaven, in describing an epidemic about Bristol, wrote a paper on " Diphtheria as a Disease of Person not of Place," and that is a good description particularly in reference to schools. An explosive outbreak may occur in a class-room, but school or class-room infection is scarcely worth consideration as a general factor.

In one case where a child had vomited (*Z.*, 1909. 735) the class-room was disinfected by the municipal officers. A week later, in bacteriologically testing the children, virulent K.L.B. was recovered from the floor. The room was again disinfected, and remained empty for eight days, when again active K.L.B. were recovered from the floor. After this no further K.L.B.'s were found. In dust a case like this is almost unique. Bacilli remain alive very long in diphtheritic membranes, but droplets with bacilli kept in ordinary daylight are dead in twenty-four hours.

Enquiries were made at one time as to such materials as modelling clay, or plasticine, and the bacilli did not live well in them. It is said that living germs have been recovered from drapery and hangings where a patient has been. From children's scarves living bacilli were obtained. Forbes found them in tooth-brushes from an industrial school. Sommerfeld shewed that school drinking vessels were often infected in the Berlin epidemic of 1911 (*Z.*, 1912. Supp., 208). A ban was placed on bubble drinking fountains where the spurt of water was less than 2 in., as the pressure is insufficient for cleansing when diphtheria is prevalent (*Ohio's Health*, 1921. 117). Lead pencils are much quoted, but not actual instances. Dudley thought that boys chewing the ends of their penholders were also a cause. All these possibilities are certain, but probably so rare compared with direct infection that they are almost negligible. In the case of books, it would be difficult to believe in infectiousness after a few hours. There are various school objects besides pencils, the stringing of beads, even sucking each other's sweets, which have been considered as possible dangers. Milk may be infected. In one case, seven University students, all in the same boarding-house, became severely affected. A milk epidemic was thus discovered, 80 per cent. of those who were affected being adults. It was traced to a cow with diphtheritic ulceration, and this again to a milker with chronic nasal diphtheria (*J.A.M.A.*, 1922. ii. 1300).

The distribution of diphtheria through the year marks it as a Winter disease. The variation of disease in Britain does not shew this to the same extent as in some other places.

Haynes published his figure, from which the curve is calculated, to shew that the Autumn increase was not due to the opening of the schools but to the seasonal drought in Carolina.

There has been a change in the age incidence of diphtheria, and also of scarlatina, which one school of hygienists put down to effects of the Education Acts. It really demonstrates the postponements of infections to a somewhat later age by care, and the consequent heaping up of increased material for the illness during school-life. Hamer has shewn how this acts in different districts of London (*L.C.C. Report*, 1918. 46). The heaping up of diphtheria mortality at school ages in recent years in London is indefensible.

The part school plays in spreading diphtheria must be very trivial, and in epidemic times it will be diffused in spite of school care.

By following up every London case notified at the ages 3 to

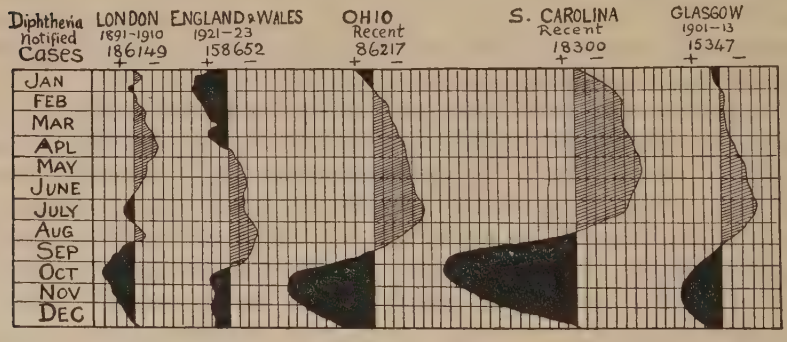


FIG. 133.—SEASONAL PREVALENCE OF DIPHTHERIA. VERTICAL DIVISIONS GIVE 10 PER CENT. ABOVE OR BELOW MEAN.

13 years, in what proved to be the heaviest week of 1909, the facts expressed in the figure were obtained. It shews that on the most liberal allowance less than 5 per cent. could have had school origin.

Small limited outbreaks in school are not uncommon and not necessarily associated with district outbreaks. Diphtheria cases have nothing to do with the general sanitary condition of the school (Niven). Investigation of drainage after such outbreaks is generally wasted money so far as this disease is concerned.

Dr. Rose shewed in Aberdeen that one might go over the various conditions in a school and have to reject each as a likely factor. It is not water supply, common to all the schools. It is not any of the various forms of ventilation or heating which have been so thoroughly tested in Aberdeen.

The *a priori* doctrine expounded by Thorne Thorne in the Milroy Lectures of 1891, "Compulsory school attendance has, in regard to this disease, prevented the fall in the death-rate that has

occurred in most infectious disease," was a product of the office chair and not of school experience.

Versmann (*Z.*, 1910. 199), in Hamburg, excluded the ordinary school as a material agent in disseminating diphtheria, and Drigalski, in Halle, in his Report for 1908–9, confirms this.

Nearly all American and foreign writers agree with Harrington, who found in Boston in 1910 that the belief that diphtheria or scarlatina are spread by school attendance is not supported by reliable data. My own judgment, based mainly on school experience, is that school is a definite but very modest factor in spreading diphtheria. It is impossible to fix a value for this influence, but certainly it will average far below 10 per cent.

Out-of-school conditions sometimes are attributed to school. There were 40 deaths among 150 persons, mostly children, as a result

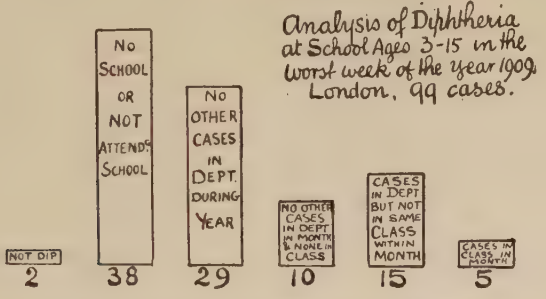

Analysis of Diphtheria at School Ages 3-15 in the worst week of the year 1909. London. 99 cases.
NOT DIP
2
No School or NOT Attends School
38
No other cases in Dept. during Year
29
No other cases in Dept. in month & none in class
10
Cases in Dept but not in same Class within Month
15
Cases in class in month
5

FIG. 134.—OUT OF SCHOOL INFECTION IN DIPHTHERIA.

of a three days' wake next door to a school-house in Pennsylvania, but this had nothing to do with the school (*Z.*, 1892. 31). In investigating diphtheria, the domestic cat may be suspected. Simmons isolated virulent K.L.B. from cats associated with a fatal case of diphtheria (*Med. Scien.*, April 1921). Webb (*J. Roy. San. In.*, 1914. 61) narrates a similar case. The M.O.H. isolated K.L.B. from three cats of nine in an institution where diphtheria was prevalent (*Lambeth Report*, 1915. 34). Savage (*M.O.*, 1920. 182) could only get diphtheroids from suspected cats, and all his efforts to infect kittens were unavailing. The matter must be regarded as still doubtful, as no experimental evidence of virulence from inoculated K.L.B. seems to have been obtained.

The class-room outbreak at its worst may be represented by a "catastrophal epidemic" recorded in the lowest class of a girl's school close to the Lehrter Bahnhof in Berlin. In the class of 41, testing shewed 35 with K.L.B.; of these, 18 had severe anginal diphtheria, and 4 died. In their families were 13 other cases with 2 fatalities.

The worst for many years in London is quoted by Dr. Forbes (*Public Health*, 1923. 323). A class where there had been no recent diphtheria had a girl at hospital absent for six weeks. Her mother had also had a sore throat. The girl (1) returned to her place in class, and in a fortnight the child in the place in front of her failed with fatal diphtheria. Another fatal case (3) occurred in the same row of the next block of seats. In the following week, a child (4) sitting next to (1) also failed, and ultimately died. Next day the child (5) sitting behind (1) failed, but recovered. Swabbing the class shewed 11 with various suspicious conditions; of these (1) and a child (6) sitting between the seats of the fatal cases (3) and (4) had virulent

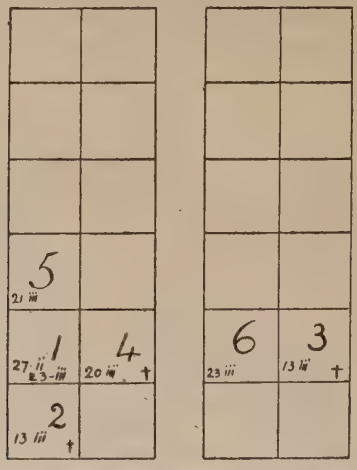


FIG. 135.—CLASS OUTBREAK OF DIPHTHERIA WITH POSITIONS IN CLASS AND LAST ATTENDANCE OF PATIENTS.

K.L.B. Of the others, 1 was suspicious and 8 negative (*Public Health*, 1923. 329).

Class outbreaks tend to this kind of localized distribution but are generally trivial in results. Dr. Thomas in London found most carriers among six-year-olds. If diphtheria attacks a child in a class under the age of 5, the probability is that the child will go down with a severe attack, and will not remain in school to spread the disease; indeed, in no single instance amongst the outbreaks which Dr. Thomas investigated was a babies' room found to be the source of a school spread of diphtheria (*B.M.J.*, 1904. ii. 431).

General Summary.—Diphtheria is still a scourge that should be prevented. Most fatalities are due to the want of early antitoxin treatment. The mortality case rate has become lower, but the numbers of cases are excessive. We still have no means of controlling the carrier of virulent K.L.B. The Schick test may be negative, the tonsils may have been enucleated, but there may

remain a focus. This can be made innocuous by making those around immune, in which case the K.L.B. does not matter.

Already the new knowledge is shewing its results in America. Dr. George Gohler of Rochester (*J.A.M.A.*, 1924. ii. 1569) last year could say, "I can recall a time when we had a death a day when the city was half its present size. Now in a city of 300,000 we have only had one resident death in four months."

This can be better set out by exact figures. Taking Detroit, during the time 180,000 children have been recorded, the cases of diphtheria occurring amongst them have been (*Ohio's Health*, 1924. 19)—

90,000 children untested and untreated	54 cases.
90,000 children tested and when positive injected with toxin antitoxin, viz.—	
80,000 Schick negative	4 cases.
8000 Schick positive, not retested after injection ..	4 cases.
1800 still Schick positive after injection	4 cases.

Some of these cases may have occurred before the full time for establishment of immunity, but the reduction is indubitable and epidemic diphtheria should cease in well-regulated communities. We have much to learn in England. The last three years' Registrar-General's Reports (1921–3) shew over 1000 cases a week, whilst London had a death-rate amongst school children excessive beyond measure, and controllable by available methods, yet not utilized.

Scarlet-fever.

Scarlatina.—Scarlatina has varied within memory from a frequent and terrible disease to one generally so mild that the patient cannot be called a sufferer.

Donally, who made a survey from 1892 to 1916 of statistics derived from millions of cases (*Med. Record*, 1916. ii. 490) stated that England had proportionately most of all places studied. He gave the case mortalities in percentages: for England, 3·3; Norway, 7·9; New York, for 40 years past, 12·2, falling recently to 4·0; and Russia, 22·0. A steady and consistent reduction in mortality is noticed everywhere except Russia, where it has doubled.

The incidence of the disease in the past can be grasped from the enormous range in the mortalities recorded, and also the recent improvements going on.

Notifications in Detroit for 1920 were as follows in percentages for each year of age—

0–	1–	2–	3–	4–	5–	6–	7–	8–	9–
0·6	2·4	49	7·8	10·5	10·2	11·1	9·5	7·5	5·3

The highest incidence is amongst children, and some 70 per cent. of cases are below the age of 10.

With any variation from this kind of distribution, and especially increased incidence on adults, some special factor is to be suspected. Clarke in Edinburgh, where adults consume milk with porridge, has suggested keeping tally on this as a mode of detecting outbreaks of milk infection (*M.O.*, 1924. 227). Milk infection may be commoner than usually suspected where only violent outbreaks are followed out to this source. A recent outbreak of mild scarlatina following consumption of ice-cream was traced to a convalescent boy (*Lancet*, 1925. ii. 79).

The mildness of many cases of scarlatina, and the considerable proportion of apparently immune individuals, made the study of the disease in London elementary schools difficult. The conclusion was early reached that about 80 per cent. of people were immune —a figure which was near reality.

Dr. T. H. C. Stevenson, figuring out the proportion statistically, found 15 per cent. as the number of leavers who would have been notified with the disease. The numbers actually recorded in secondary schools were 17 per cent.

When secondary schools are considered, the proportions are much reduced.

Kobrak (*Zeit. f. Kinderheil.*, 1920. ii. 137) noticed that contagion occurred more frequently in well-to-do families with spacious homes than under unhygienic conditions. He attempted an explanation in the doctrine that over-fed children as a rule are more inclined to throat infections, and contract scarlet-fever more readily than the under-nourished.

Hamer, in connection with his flea hypothesis, explains the increased incidence of scarlatina on better-class school children to the postponement of attacks from infancy till school-days, and consequently "bad" schools, from the flea outlook, shew less scarlatina.

For six large sanitary districts of Glasgow attack rates of scarlatina among children under 10 diminish as room density increases. "No matter how much stress may be laid on the lack of notification in the lower parts of the city as explaining the discrepancy, such a difference cannot be explained away" (Brownlee, *Special Medical Reports*, 18; *Phthisis*, 37). His table is of value in explaining scarlatinal distribution. It has been criticized adversely in that the number of children proportionately is variable in the different districts, and that during the period there were two outbreaks of milk-borne scarlatina which chiefly affects adults.

Reactions of Scarlatina.—It is his figures of these death-rates, varying from the 388 in the roomy house to 138 in the crowded rooms, which serve to establish the doctrine of immunization by minimal or subinfective doses that goes on in urban life. Disease diminishing the more frequent are contacts, here in Glasgow three

times as much between highest and lowest. This diffused sub-infective immunity is the protection which causes notified scarlatina to be rarer the lower the social level, and is a home, not a school product. Where in a community this process has not had effect all classes suffer, but still the children most frequently.

Hamer does not seem to agree with this doctrine of minimal infections, and from analysis of medical inspection cards suggests that there is considerably more scarlet-fever among pre-school children in poor districts, with consequent exhaustion of the material for infection during school age. The real test of the value would be deaths. Whatever be the cause, for two or three years after entry to school "the incidence upon children in the good schools is nearly double that upon the poorest children." Hamer's analysis is more ingenious than convincing. It is quite probable that a

Table 92.

BROWNLEE'S TABLE.

District of Glasgow.	Population.	Number of Children under Ten.	Number of Persons per Room.	Scarlatinal Cases, 1898–1902.	Attack Rate per 10,000 Children.
I	34,868	4451	0·5–1·0	864	388·2
II	83,255	13,605	1·0–1·5	2148	315·6
III	201,098	43,173	1·5–2·0	5439	251·8
IV	87,885	20,834	2·0–2·25	2186	209·6
V	237,161	56,898	2·25–2·50	5610	197·0
VI	117,445	30,185	2·50–2·75	2091	138·4

general theorem of "salting" will ultimately be proved in regard to contagious diseases, in addition to exhaustion of the material by disease.

In 1873, Thorshavn in Faroe, then with a population of 930, had 236 cases of scarlatina. There had been no case within the generation alive, and except the old people, all ages suffered. Three-quarters of the adolescents and a quarter of the adults went down with it.

Infection is mainly from personal contact, but may be very tenacious in fomites, although this mode is rare. The third party carrier is common and easily found.

In London, a seasonal prevalence distributes the mortality below the average in the Spring and early Summer, and above for the rest of the year.

Scarlatina has always seemed a puzzling disease, because not only may it occur in forms varying from the most virulent to a mildness almost unrecognizable, but conditions indistinguishable from it are associated occasionally with wounds, septic burns, or

the puerperium. Some cases, too, may easily be confused clinically with slight diphtheria. Attempts to treat it with the serum of convalescents had met with modified success. Schultz and Charlton (*Zeit. f. Kinder.*, 1918. 328) described a skin reaction. The intradermal injection of a cubic centimetre of serum from the majority of normal persons, or from a scarlatinal convalescent, produces in the eruption of a scarlatinal case, a lasting blanching of an area up to an inch or two across. Serum from an active case of scarlatina does not act in this way. The serum of certain normal people who have not suffered scarlatina also fails.

It suggests toxins and an antitoxin in the disease.

For years, the presence of hæmolytic streptococci had been associated with this disease, as they are generally found in scarlatinal cases. The artificial production of the disease itself by means of the streptococcus had not been achieved. Russian workers, Savchenko and Gabritschewsky, had determined a toxin, and related it to streptococci and prepared vaccines, with which some 50,000 people were treated in 1907–10. Moser of Vienna also had a toxin, but there was no way of assessing either the strength or value of these methods.

Dick Tests.—As the result of long work with the streptococci, G. F. Dick and Gladys H. Dick in 1923, with a strain isolated from the septic finger of a scarlatinal nurse, succeeded in imparting the disease to persons who were without the partial immunity conferred by residence in towns. They then isolated a toxin from cultures, and found that intradermal use of small quantities produced an areola of rash which appeared in about twelve hours and disappeared in a couple of days. If the toxin had been boiled for an hour, it did not give this reaction. With this as control advance has been rapid.

A person who is immune to scarlet-fever does not shew this areola. Its presence or absence constitutes the Dick reaction, similar but more rapid and evanescent than the Schick test for diphtheria. The reaction has not yet been finally standardized (1925) so that its assessment is not as definite as Schick.

The effect of this toxin injection can be neutralized if the toxin is mixed previously with serum from a recovering patient. There is evidently an antitoxin in the convalescent's blood.

A positive Dick reaction shews absence of scarlatinal antitoxin in the blood and liability to contract disease by infection. A negative reaction shews presence of enough antitoxin to prevent symptoms from infection. Active immunity can be set up by repeated small doses of toxin. It is rapidly acquired, and has so far lasted for eighteen months.

The next step was to prepare a potent antitoxic serum for protective and curative use in fever, by strongly immunizing horses.

The result of this mass of work is that scarlatina in its various aspects can now be interpreted as very similar to diphtheria, except that the scarlatinal toxin more readily educes its antitoxin.

Zingher (*J.A.M.A.*, 1924. ii. 432) has reviewed the public health aspects of this advance. The various strains of streptococci contain some which are specific for scarlatina. These may infect the naso-pharynx or form a local lesion in the throat, infect wounds or open surfaces. Toxin is produced. It does not necrose the tissues like diphtheria toxin. A reaction takes place. Antitoxins are produced and recovery follows. Its effect is antitoxic, not antibacterial, so that various local septic results may occur, and the case may still be infective to others.

The antitoxin produced or present in blood serum causes recovery. This antitoxin can be either result of natural active immunity, or it may be passive from use of a therapeutic serum.

In New York it has been determined by the Dick tests that a new-born babe has passive immunity from its mother, if she herself is immune, and that this persists for about six months. In the second six months of life in an ordinary lower middle class child, about 64 per cent. give positive reactions. In the 1–2 years about 70 per cent., and then it gradually falls. At school age, about 5–15 years, 25 per cent. give positive reactions. The rest, by "salting," have gradually acquired immunity. Testing better class private schools, about 80 per cent. gave positive reactions. Their sheltered lives had cut them off from naturally acquired immunity which three-quarters of an ordinary city population get in the street or homes. English results have confirmed these.

Moscow observers shew that the percentage curve of positive Dick reactions in various age groups of population is paralleled by cases of scarlatina notified per 10,000 children living at each age group (*J.A.M.A.*, 1925. i. 1476), thus confirming the accuracy of the Dick test.

By these means a field has been opened for further exploration of scarlatina, which should lead to its control. This test gives a possibility ultimately of estimating relative immunity, of effecting diagnosis, and is an indicator as to need for immunizing by antitoxic serum.

Causes of the disease are specific strains of this group of hæmolytic streptococci. Infectivity is comparatively low. Subinfectious doses confer considerable immunity. The incubation period may vary with individual resistance from twenty-four hours to a week or more, with an average of about three to five days.

In the first clear case of inoculation, the Dicks found a faint scarlatinal rash in forty-eight hours after swabbing the throat with the streptococcus.

A horse serum prepared by Dochez using the hæmolytic strepto-

coccus which blanches the scarlatinal rash has been used for curative purposes (*Bull. J.H. Hosp.*, February 1925), but is apparently of doubtful use (*J.A.M.A.*, 1925. ii. 95).

Pirquet's life is said to have been saved in an attack of septic scarlatina by the use of a serum prepared in Vienna (*Wien. M. Woch.*, 1924. 106), where Moser had proposed such treatment in 1905.

Onset of Disease.—In a typical case of pronounced scarlatina invasion is sudden. The only school illness in this respect to compare with it is in some few influenza cases. When possibility of scarlatina is in question any subjective sore throat, any redness of fauces, a rapid pulse, or feverishness, should be taken as sufficiently suspicious to call for exclusion, isolation, and careful observation. Headache, giddiness, nausea, or vomiting so suddenly that the child does not leave its place in class, may be school onset. Vomiting occurs in perhaps 20 per cent. The face is often flushed, and pallor around the mouth shews. The pulse is quick and temperature rushes up. In a few hours rash appears about the chest, arms, and neck. Fine red points on a scarlet erythema, sometimes it is quite thick and raised, and may even shew little straw-coloured vesicles the size of pin-heads. The eyes do not have catarrhal appearance as seen in measles; they may seem sunken and pale. There are no Koplik's spots. The tongue may be furred with strawberry-red points, or at first just red and rough. Usually there need be little anxiety about the patient. The onset may be severe. A fine, well-grown girl was seen in school, cold and collapsed, needing heat and stimulants ere removal to an ambulance, then doing well on the appearance of an intense rash.

Time of Onset.—Murphy, noticing certain weekly returns, to be discussed under holiday influence, assumed that schools were important means of distributing scarlatina. It was attempted to demonstrate the hypothesis he had originated. By tracing back infection from invasion, or appearance of the rash, it was sought to shew that there was less infection taking place at times when schools were closed, as, for instance, Saturdays and Sundays. However, Brownlee found (*Public Health*, 1905) that age-incidence alterations gave no suggestion of school spread of scarlatina, and that the day of sickening shews no school influence. He published figures from which Whitelegge in Nottingham (1887) thought he could deduce a minimum infection at the week-end.

Goldsmith tabulated dates of appearance of the rash, which he found least on Tuesdays and assumed that this indicated least infection on Saturdays and Sundays (*Lancet*, 1907. i. 1765). Williams in Sheffield found Wednesdays and Thursdays as days with fewest cases.

In London, of 100 cases followed out in detail in a closely studied

district, 40 were last at school and well on Friday, and absent ill on Monday.

Ewart also examined daily incidence (*J. of Hygiene*, 1916. 220), and concluded from this that school distributes scarlet-fever to approximately the same extent as home or other external influences.

Even if it is assumed that Saturday and Sunday are free from risk of infection, the variation in time of incubation is greater than the differences to be measured by the week-day, so that as a scientific method this cannot be expected to give a solution, and when the time of the appearance of the rash is taken, the interval becomes more indefinite. Nothing conclusive has therefore emerged.

The clinical possibilities of the outcome of the illness in any case are beyond school, and must be sought in other books.

Occurrence of acute suppuration of the middle ear in about 15 per cent. hospital cases ought to be noted, as it gives rise to a considerable amount of deafness or partial deafness of educational importance.

On one occasion the writer operated for acute mastoid disease on a boy about 12 years of age, and next day found him covered with a thick scarlatinal rash. He had to remain twenty-four hours in a small ward with three other boys, none of whom contracted the disease, although all were liable in that they had not already suffered.

Desquamation.—With disappearance of the rash, the skin is a little rough and desquamation begins by small pin-holes, fine flaky scales, and later coarse casts. The backs and sides of hands, sides of the finger-joints, or wrists where rubbed by the coat, are parts generally noticed in school where a child is detected in a peeling condition. The skin is not invaded by the streptococcus, rash being due to a toxic circulatory disturbance. The germs are not found in the skin.

There is no reason to suppose that the epithelium is contagious in itself. It may, of course, convey infection, from soiling by other discharges. We have followed out many cases found peeling in class, some of which might have been infected by previous cases in school, but there never was a subsequent infection. In desquamating cases allowed to go on in school, no further infection occurred. These scarlatinal cases, in view of rare sequelæ, would perhaps be better if rest could be secured for a time, but all things considered, they are probably as safe in school as excluded.

Some years later, a list of 30 "peelers" observed in London schools was compiled by one of my colleagues. One or two doubtful but possible sequelæ were noted (*L.C.C. M.O. Ed.*, 1909. 60).

Dr. Rennett, in his *Chester Report*, 1922, writes: "Cases of scarlet-fever are discovered in all stages of desquamation attending school, and going about freely, yet it has so far proved the

exception to be able to connect one of these ambulatory cases with any other."

Unless there was some discharge or other cause for suspicion, a case should not be regarded as infectious merely on account of desquamation.

All peelers are not scarlatinal, as any skin hyperæmia of an intense degree may cause a desquamation. Some of these cases tested by Zingher in New York gave positive Dick reactions, shewing them not immune to scarlatina (*J.A.M.A.*, 1924. ii. 445). But even scarlatinal peelers, not otherwise detected, were probably only of very scanty importance as sources of infection before the peeling began.

School infection in London was originally assumed as playing a considerable part in diffusion of scarlatina, but the more we investigated the problem in schools for ourselves, and disregarded mere opinions, the more it was attempted to trace sequences, the more evanescent they became, till school was seen to take but a minor part.

Dr. T. H. C. Stevenson examined class influence of vomiting in school, as the rule then followed was to evacuate the room for the day, and disinfect thoroughly. Cases where vomiting had occurred were not followed by other cases, any more than cases which had been last present in school without sign of illness, which are about four-fifths of the number (*L.C.C.*, 1907. 42). At this stage also infection is uncommon.

Scarlatinal investigations did not furnish the positive returns hoped for. "We have ascertained that the peeling stage of scarlet-fever is of little importance as regards infectivity, and also that a large proportion of people escape the disease. The manner of outbreak in school, each case usually in a different class, and the difficulty of tracing direct effects of cases, point to the want of immunity in certain individuals as the most important factor in scarlatinal dissemination (*L.C.C. Report*, 1908. 47). The mode of invasion of a school is against school infection; for instance, the largest school in London when invaded by scarlatina had the first 17 cases notified from 15 different class-rooms. In a particular district studied, 100 cases were notified from 42 schools, distributed in 85 class-rooms. In Zurich 1519 cases in the public schools were distributed in 1153 different classes (*Schw. Med. Woch.*, 1922. 145).

Carrier Cases.—Dr. A. H. Hogarth attempted to trace infection through carriers and thought of finding school effects in this way, but he could only find rare examples in school, when children with sore throats had apparently formed links in the chain of infection.

As an illustration of school possibilities in a missed case, one of his examples is shewn in Fig. 135. Six cases of scarlatina occurred in two classes of an infant school. A girl had a sore throat for a

couple of days before absence from scarlet-fever. Two girls next her both absented themselves from this cause, never having been ill in school; another was absent from tonsillitis, probably scarlatinal. No further cases were traced from these. D was probably infected by her sister, a "missed case," C, as the girls sitting on each side of her absented themselves with fever, never having been ill in school. C had had a slight sore throat and was excluded. She had played, out of school, with another girl, B, in the same class who was excluded on account of fever in the house, the baby, A, being ill, and B later.

The intervals in days are stated on the chart, and any symptoms noted in school.

In spite of the difficulties of dealing with scarlatina, it is only constant enquiry, and constant facing of difficulties, which will

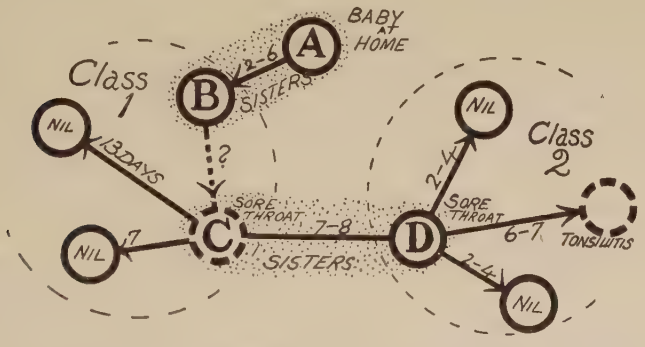


FIG. 136.—CHAIN OF INFECTION TRACED BETWEEN VARIOUS CASES OF MILD SCARLATINA, AND ALSO SCHOOL SYMPTOMS NOTICED (A. H. HOGARTH).

bring about saving knowledge. We had our search much hindered by rule-of-thumb proceedings of various officials.

A child who was desquamating in school without any previous history of illness was excluded on February 5th, and although there was no subsequent case, ten days later, on February 15th, the department was closed for fourteen days by the Medical Officer of Health—a wholly insufficient time for clearing up of any active infection in sufferers, if it had been present, and closure needed.

Whilst Detroit officially assigns 3 per cent. of its scarlatina cases as school infection, the majority of our own sanitary officials still seem to think of diseases, and especially scarlatina, as largely school distributed. Undoubtedly this arises as an aftermath of Murphy's long-asserted doctrine of holiday influence. Quite recently (*Lancet*, 1923. ii. 455) a Medical Officer states: "The most important factor in the spread of scarlet-fever is school attendance, the disease waxing and waning according as the public schools of

the borough were open or closed during the year, allowance being made for the pre-school period of life, which always accounts for a considerable number of cases."

This refrain from the past was scarcely supported by the chart which he published.

Now that transfer of a streptococcus is recognized as the machinery of infection, sore throat, always held worthy of attention, becomes more important. Cases who become ill are probably absent from school before marked infectiousness arises.

The difficulty in control of scarlatina lies in the "missed case." Ewart suggested that the nature of the rash to some extent might depend on inherited qualities. For a considerable time in the London School Service we were inclined to think that immunity itself might have heredity as a considerable factor.

Various Hypotheses.—For instance, the recent record of a respectable family whose members were well looked after was: Harriet T., a girl of 11 at a Central School, contracted scarlatina, and eight days after her return from hospital her sister Annie, aged 9, at the girls' department of a Council school, failed with the disease. Returning from hospital some weeks later, Annie in five days appears to have infected the next sister Ivy, aged 7, in the infants' department, and she sickens. On her recovery and return home, eleven days elapse and Gerty, aged 5, goes off with scarlatina. Coincidence needs a long arm to explain these. Family disposition, as shewn by Ewart's calculation of a high correlation in the reaction to scarlatina of parents and children, is a more likely suggestion. Incidentally, in working out this solution, Ewart estimates that 40 per cent. of cases are "missed." In a later paper he analyses scarlatina as he saw it at Barking, and concludes that, of cases shewing definite discomfort, only 50 per cent. are notified; of the total number of cases only 10 per cent. (at most) come under control. With his estimates the writer fully agrees. Segregation may avoid massive infection in the home, but all the segregation possible will do little to put an end to the general infection which makes the disease endemic.

In America and parts of Canada there are still quarantine regulations which read like extracts from civic rules of the Middle Ages, and even with the ignorance of immigrant aliens that go into the melting-pot of America, quarantining of houses can scarcely produce a useful effect compared with the social disturbance resulting.

For England the subject may be left out of discussion.

Fleas have been suggested as a means of disseminating this disease. Much work has been expended on this point in the past ten years in London, and much ingenuity in explaining away discrepancies. The diagrams published in the annual *L.C.C. Reports* have long satisfied me as conclusive that any direct relation is negligible between the number of notified cases of scarlatina, and

what Hamer, who fathers the " flea hypothesis," records as an index of the prevalence of fleas. The subject is still being kept under observation, although a " carrier " flea has yet to be demonstrated, or mechanism of conveyance to be suggested.

The infectivity of scarlatina usually disappears with the rash. Cases taken into hospital are generally kept a month as a routine ere discharge, and about 4 per cent. on return home set up return cases by later infection. It is said that if treated in open air the return percentage is halved. There are a few chronic carriers, usually with some discharges. Otitis and nasal secretions are credited as being chief. Cases may persistently infect, and yet appear in perfect health.

In the first six months of 1922 some thirty-two cases occurred in connection with Addenbrooke's Hospital. They were attributed, and a few directly traced, to a wardmaid who had frequent sore throats but otherwise was well. She had escaped scarlatina when the rest of her family had it ten years earlier (*Med. Officer*, September 1922). Dr. Young (*Public Health*, March 1922) relates the case of a boy who had scarlet-fever, and three months later tonsillitis. He appeared well, but began infecting relatives and friends, till six months later anti-catarrh vaccine was used and the inferior turbinates cauterized, when with disappearance of the nasal catarrh his infectiousness ceased.

One famous carrier recorded was R. C. She appeared first in the rôle of scarlatinal and later of diphtheritic carrier. This persisted in virulence for a couple of years, but for several years after, when she had become avirulent, any recurrence of even doubtful throat illness in her neighbourhood was attributed to her. She harboured diphtheria bacilli for at least five years. As she had enucleation of the tonsils done, probably there was some septic focus about the nasal sinuses in which the scarlatinal streptococci lingered until replaced by diphtheritic micro-organisms. The virulent ones died off, leaving a persistent non-virulent strain of K.L.B.

The last outbreak of scarlatina which the writer personally investigated began with three notifications from the same class in a girls' department on three successive days. These seemed of interest as a school outbreak, but were found to be quite separate infections. Following them out led to 639 cases, and twelve schools coming into the enquiry. All houses were visited, and a diary of illnesses made out. The broad result was, low infectivity of the disease, its localization, domesticity, and recurrence in houses, and absence of any class infections. Nevertheless, about 20 per cent. of the mild cases had only become known through the schools, which played a passive part except as related to proximity to the affected district. A detailed account with a spot map shewed that district infection was the main condition (*L.C.C. M.O. Ed.*, 1911. 121).

My own conclusion is, that whilst rarely an urban school may be the medium of a limited infection, its influence in causing illness from scarlatina, at school or other ages, does not amount to more than 5 per cent. of all known cases.

Smallpox.

Smallpox fortunately does not trouble the school doctor much, but it is important that it be not overlooked. Whilst free vaccination is offered to all, it should be illegal to spend public money on any other special provision against smallpox. Still, children have to be protected against the risks which many of them run for want of this suitable protection.

It is the duty of the school doctor, as of the Medical Officer of Health, to seek out all the conditions inimical to health. As smallpox is now infrequent, it is probably not worth listing the names of the children protected by vaccination and those who are unvaccinated. In the case of smallpox occurring in a school the inspection of vaccination should under no circumstances be postponed. It is the statutory duty of the Medical Officer to inform himself of all circumstances affecting health, and vaccination should be offered to every unvaccinated child. The writer, requested by a Committee not to examine children under such circumstances, at once declined. He is the general in command in this war, and must override any opposition in emergencies.

A red ribbon to be worn as a band around the vaccinated arm is good propaganda; the children want to wear it. The smallpox of last century was a terrible affair. Much of the smallpox in recent years is so mild that it seems no more important to schools than influenza, and may be regarded as an efficient form of spontaneous protection and useful to the public health. It is scarcely worth troubling about.

Unfortunately, there is no guarantee that it may not at any time take on the old virulence. In any case the safe rule is to surround every sufferer with well-vaccinated contacts.

Vaccination is being neglected through ignorance and *laissez-faire*. Millions of adults were vaccinated during the War. The school entrants are mostly unvaccinated, but leavers are vaccinated.

Want of efficient vaccination should be assessed as a defect on any score card for children for scholarships, camps, and otherwise.

In Dumbartonshire (1922) the unvaccinated were: Entrants, 40·2; eight years old, 30·1; twelve years old, 15·8; and sixteen years old, 3·2 per cent. In Gloucestershire (1921): Entrants, 67·6; intermediates, 61·7; leavers, 44·6 per cent. But rate of omission of vaccination seems to increase rapidly. Stockport averages: 1917, 24 per cent.; 1918, 33·1 per cent.; 1919, 42 per cent.

In Govan, during the War years from 1914 on, the percentages unvaccinated were : 14·5, 14·2, 19·0, 21·6, 24·6, 27·9.

In the year 1921 Newman reported that of 46 cases of smallpox under 5 years old, 45 were unvaccinated.

In a recent epidemic in Glasgow, of children under 15, there were 30 cases who were vaccinated and none died, whilst there were 112 unvaccinated, of whom 38 died.

In the year before the writer began work in London a smallpox outbreak occurred. The case- and death-rates per million living were—

Table 93.

Vaccinated (including Doubtful Cases).			Unvaccinated.	
Age Group.	Case-rate.	Death-rate.	Case-rate.	Death-rate.
5–7	243	8 (0)	5015	1100
7–10	433	23 (5)	5892	850
10–13	687	23 (9)	6351	1361

The death-rates for vaccinated (not doubtful) are given in brackets (*L.C.C. Med. Off. Educ.*, 1906. 32).

Even those vaccinated in infancy require revaccination, and much of the attention of French school doctors appears to be taken up with revaccination of children.

The effects of vaccination were evidenced in a smallpox outbreak which threatened the success of the great Exhibition at Glasgow in 1901. In a population of 675,887 not recently vaccinated, within fifteen months 404,855 persons were vaccinated. There were 271,032 who refused vaccination. There was not a single case of smallpox among the revaccinated, but 1858 cases among the others.

A school child, but not the school, was origin of a London outbreak. She was a mild, unreported case, found during a school inspection, after eight other cases of smallpox had been reported from the school. She was then noted to have traces of a rash which had appeared three weeks before. Non-recognition of her rash earlier had, however, led to 59 other cases (Wanklyn, *School Hygiene*, 1921. 24).

Discussions occasionally occur about testing risks of exposure of vaccinated and unvaccinated to contact with smallpox. It would be illegal, and is unnecessary, for what was almost a laboratory experiment is the result of a school infection at Common-side, Ossett.

On October 27, 1904, the teacher observed a girl aged 11 in class with a rash on her hands and face. The doctor diagnosed smallpox. All precautions were taken. In that class-room were

27 boys and girls aged 9 to 13 years. Of these, 8, including the affected girl, were unvaccinated, 13 vaccinated in infancy, and 6 also revaccinated. By November 10th, the end of the period of incubation, all the unvaccinated had gone down with smallpox; all the rest remained free (*B.M.J.*, 1905. i. 98). It was two years after this that the Act of 1906 established the "conscientious objectors," who in fairness ought to be allowed to "object" at their own cost financially.

In Leicester, where 90 per cent. of the children are unvaccinated, Millard found that whilst a larger proportion of children were infected than would have been the case in a well-vaccinated town, they were mostly infected by adults.

Smallpox is scarcely dangerous to others in the incubation period, and the onset being sudden, a child sickens and is too ill to attend school before it has become infectious. On the other hand, when modified by vaccination, done perhaps a dozen years before, there is a chance that it may have a trivial attack, which does not prevent it going about freely and infecting susceptibles at school and elsewhere.

The only cases diagnosed in school by the writer as possibly smallpox turned out to be the milder chicken-pox. In unvaccinated children there might be doubt, but vaccinated would very rarely suffer smallpox in school-days. With smallpox, illness is felt two or three days before the eruption, whereas in chicken-pox, except perhaps for *malaise* in the preceding twenty-four hours, the patient feels well till the rash appears. The clear watery blisters of chicken-pox are usually in several crops, compared with the one crop of soft reddened papules of smallpox, becoming hard, then yellowish pustules in a few days.

Uncomplicated smallpox is usually illness two to three days, papules three days, vesicles three days, then pustules.

Sometimes a chicken-pox bleb stands on a reddened inflamed areola like a vaccination pustule. In cases where it is doubtful which disease a child has had two or three weeks previously, the method described by Ricketts for all cases gives a solution.

Ricketts determined the chicken-pox rash as centripetal. It increases from the periphery to the centre of the body, whilst smallpox is the reverse. Thus, if there were more spots on the face, hands or feet than chest or abdomen, it would be smallpox, if equal or less, chicken-pox; similarly for the hand, forearm, and arm.

Although it is doubtful whether schools play any great part in distributing smallpox, if a great outburst came there would probably be an outcry for closure. Yet as Wanklyn's case shews, they afford an opportunity for watching and catching early cases of ambulant disease, any one of which may be a source of great expense and disease.

Teachers should be vaccinated. The only fatal case of smallpox in a teacher known to the writer was unvaccinated. The *New York Health News* (1925) narrates the case of a teacher who strongly advised two mothers not to allow their children to be vaccinated. The advice was not followed, but the anti-vaccinist teacher herself died of smallpox in less than a month (*J.A.M.A.*, 1925. ii. 1085).

Other Diseases.

Mumps or Epidemic Parotitis is a comparatively frequent, but non-fatal disease in schools. The usual case lasts for a day or two up to a week, and no further trouble ensues. The child is ill, swelling and tenderness of one side of neck and parotid region develops either at the time or within the week the other side is affected, and then subsides. It may also occur in latent forms without the parotid swelling. This is noticed in boys. There is some *malaise*, tenderness is felt about the inguinal ring or even in the testicle, ovaritis may occur in girls, and occasionally atrophy and resultant sterility is said to follow.

One very rare result of mumps is deafness. Usually unilateral, and without giddiness, vertigo or vomiting, it may be bilateral nerve deafness. It comes on quickly in a couple of days, and is total and permanent. A child of 4½ years old, after a short absence for mumps, returned to the infant department. He had become completely deaf, and within six weeks ceased to use words. He was transferred to a deaf school.

Glandular Fever, or infectious mononucleosis, is rarely diagnosed in connection with primary schools. There were several outbreaks in London schools in 1920–2. It occasionally appears among boarders. A sudden *malaise* with pain on movement of the head, possibly with red swollen tonsils, then tenderness and swelling of the lymphatic glands. There is often abdominal pain and high fever. Apart from rare diseases, blood changes are diagnostic, there being a great increase in non-granular mononuclear cells. Sufferers should be regarded as infectious, and kept quiet till the swelling has subsided in about a fortnight, but they are often left weak and anæmic for a month or more.

Epidemic Nervous Diseases are rare in school practice, but tend to become more prevalent. They are distinct, but all probably infective by nasal secretions, and often mistaken for influenza. They are *poliomyelitis*, chiefly affecting pre-school ages in country districts; *cerebro-spinal* fever is commonest at school ages in town children, and *encephalitis lethargica* commonest after school ages.

In all three it is probable that carriers are numerous, and actual disease invasion is almost of the nature of an accident. Yet the school doctor must always have them in mind. Their slight

infectivity does not raise questions of exclusion or quarantine, although some American cities exclude poliomyelitis contacts for three weeks. These three diseases were made compulsorily notifiable in England in 1912.

Poliomyelitis, the infantile palsy, occurs sporadically, and also in small outbreaks, often not known till they are over. For instance, 88 cases of crippling in Plymouth were traced, long after, to an outbreak in 1911.

It rarely infects more than one in a family, although the writer has known three sisters under 6, all paralysed at once. Carriers are said to be frequently adults, and very persistent (Sweden, 1912). Flexner regards ordinary cases as free after six weeks. Its chief time of prevalence is dry and dusty weather in the late Summer or Autumn, and the organism can survive in dry dust. R. W. Lovett had the general rule, "in late Summer suspect every ailing child."

A case suspected in school, from slight illness, pains, and then perhaps weakness or even lameness, may lead to discovery of other pre-paralytic cases. Abortive cases occur, particularly difficult to distinguish from influenza. It is important that cases should be caught early, to be placed at once in physiological rest, whilst the process is active, as this gives best chance of the minimum damage in the way of crippling. Its cost to the community in later crippling is considerable.

Sometimes an outbreak may be severe. In New Zealand in the Winter of 1924–5, schools were closed, and no child allowed to travel without a permit. Between Christmas and the end of February, there were 800 cases with 127 deaths. The use of serum, 30 c.c. or more, from convalescents has been strongly recommended in both New Zealand and in the discussion at Melbourne (1925).

Cerebro-spinal Fever is fatal in over half the cases known. The fatality in infants is very high, and also after the prime of life. It is more prevalent in Spring, and with conditions of overcrowding, fatigue, and want of ventilation. It seemed associated with War conditions and is now returning to its pre-War rarity. It is endemic as posterior basic meningitis of infants. The meningococcus associated with it is a very tender and short-lived organism, which will not stand drying. There are numbers of persons who are carriers—it is said ten times as many as patients—but they do not persist longer than patients, and cases of the disease are rarely notified. In 1921 the cases notified were fewer than the deaths certified. Many cases of deafness originate, and a few anomalous mental cases are ascribed to an attack of this disease. Usually outbreaks are very limited, but an outbreak in Glasgow in 1907 had about 600 fatalities.

Encephalitis Lethargica is most important educationally on account of psychical and motor sequelæ (p. 411). It may occur at

any time or age. Illness, depression, irritability, with some ptosis or oculo-motor palsy causing double vision, are the earliest signs. An intensive outbreak was described where four girls fell asleep in the same class in a Warwickshire school. It recalls functional epidemics. Here they had comparatively slight disorder and finally made complete recovery (*Lancet*, 1923. i. 379).

Attacks or even epidemics of hiccup, the attack lasting several days, occurred associated with, or replacing, epidemic encephalitis.

Epidemic Jaundice as a specific contagious disease occurs not rarely in Britain in small outbreaks, chiefly in the late Autumn, and affecting perhaps a score of children, mainly in isolated villages. Rats possibly play a part. It is almost confined to school ages, affects both sexes about equally, and gives rise to no serious symptoms, although rare fatalities are recorded.

Avoidance of Infection, by Isolation.—This is of extreme importance in residential schools, and forms the working basis of practice in the primary school. The collated experience of many observers in the past forty years is gathered in the *Code of Rules for the Prevention of Infectious and Contagious Diseases*, 8th Edition, 1923. It has been mainly used in the following table of incubation, quarantine, and minimum isolation for patients.

Table 94.

	Days' Incubation.	Days' Quarantine.	Minimum Isolation of Sufferers.
Varicella (chicken-pox)	11–19	20	Till all scabs fall
Variola (smallpox)	10–14	16	
Morbilli (measles)	10–14	16	*7 days after rash
Rubella (German measles) ..	9–18	20	7 days after rash
Epidemic roseola (rose rash) ..	9–18	20	7 days after rash
Scarlatina (scarlet-fever)	1–8	10	4 weeks
Diphtheria	2–10	3 negative swabs in week	
Mumps (epidemic parotitis) ..	14–23	24	14 days
Whooping-cough (pertussis) ..	7–19	21	14 days after cough has ceased
Sore throats	24–36 hours	Until well	

* *The Code of the M.O.S.A.* puts measles fourteen instead of seven days here.

The incubation of cerebro-spinal fever appears about three to five days; acute poliomyelitis from two to ten days. The polioencephalitis about the same period, very variable. Encephalitis lethargica probably within two to fourteen days. For these quarantine is unnecessary, except in presence of an acute epidemic.

School Attendance and Zymotics.—In my first years of school-work, previously referred to, an extensive outbreak of measles in

a school, beginning three or four days after a sixteen days' Christmas vacation, turned attention to this extra school spread of disease. At another time this might easily have been taken for a class-produced outbreak.

Everyone working in schools has similar experience. A case of scarlatina outbreak is recorded in the *London M.O. Ed. Report*, 1909. 65, among infants going for the first time to school.

A " holiday influence " was regularly demonstrated by Murphy in London for many years, but, as he pointed out, it began before the holiday and lasted after. He seemed to think that schools caused a diffusion of infection which ceased in the vacation and which was demonstrable in comparing children of older and younger groups with those at the usual school age. The form it was put in may be taken for 1892–3–4 in relation to diphtheria notifications, and 1903–7 for scarlatina (Table 95).

The total figures for the London population in the nineteen years of 1892–1910 were given in the *L.C.C. Public Health Report*, 1910. 51, as enumerated in Table 96.

For at least a dozen years, public health practice was influenced, and progress of school hygiene in this country seriously damaged, by the delusion thus fostered that schools were serious disseminators of disease.

Apart from exaggerated statistical methods followed, a worker in the schools could object, that three considerations were omitted, any one of which might account for the effect displayed—

(1) The effect of retarded announcement of disease, decreasing the notifications before and increasing those after the end of the holiday.
(2) The effect of exodus of children from London during the vacation. This corresponded in a very large sample worked over to about 20 per cent. reduction of child population.
(3) The effect of school attendance enquiries in bringing to light cases of scarlatina or diphtheria otherwise unknown.

In an enquiry this was found to be 20 per cent. (*L.C.C.*, 1911). Even if only half these values found were taken, and the real numbers of cases in the total child population remained steady over the whole period, the statistical method employed would give fluctuations in the cases notified such as were displayed in the *L.C.C. Reports*. The whole interpretation of the figures was incorrect. The Battersea enquiry, when every child in the district was examined medically the week before and the week after the vacation, and a complete list of all the diphtheria cases at school ages and their origin published (*Report*, 1909. 66) finally settled the question.

TABLE 95.

Notifications, London.	Diphtheria, 1892.			Diphtheria, 1893.			Diphtheria, 1894.			Scarlatina, 1903–7.		
Age Group	0–3.	3–13.	13–	0–3.	3–13.	13–	0–3.	3–13.	13–	0–3.	3–13.	13–
Percentage in holiday weeks over preceding month	+20	−3	−10	+8	−27	+1	+11	−24	+4	+3·8	−14·7	−5·7
Percentage of succeeding month over holiday	−7	+29	+34	+6	+81	+33	−10	+44	+11	+3·2	+44·9	+33·6

TABLE 96.

Period in Relation to Holiday Period.	Scarlet Fever.			Diphtheria.		
	Notified Cases.	Increase (+) or Decrease (−).		Notified Cases.	Increase (+) or Decrease (−).	
		Cases.	Per Cent.		Cases.	Per Cent.
Four weeks preceding	32,862	—	—	15,506	—	—
Four weeks coinciding	28,312	−4550	−13·9	12,815	−2691	−17·4
Four weeks following	38,144	+9832	+34·7	16,184	+3369	+26·2

Under ordinary circumstances either school or holiday influence is trivial in regard to the zymotics. In 1923 an epidemic of scarlatina in Islington " was maintained throughout the period of the holidays when the schools were closed, and school infection cannot

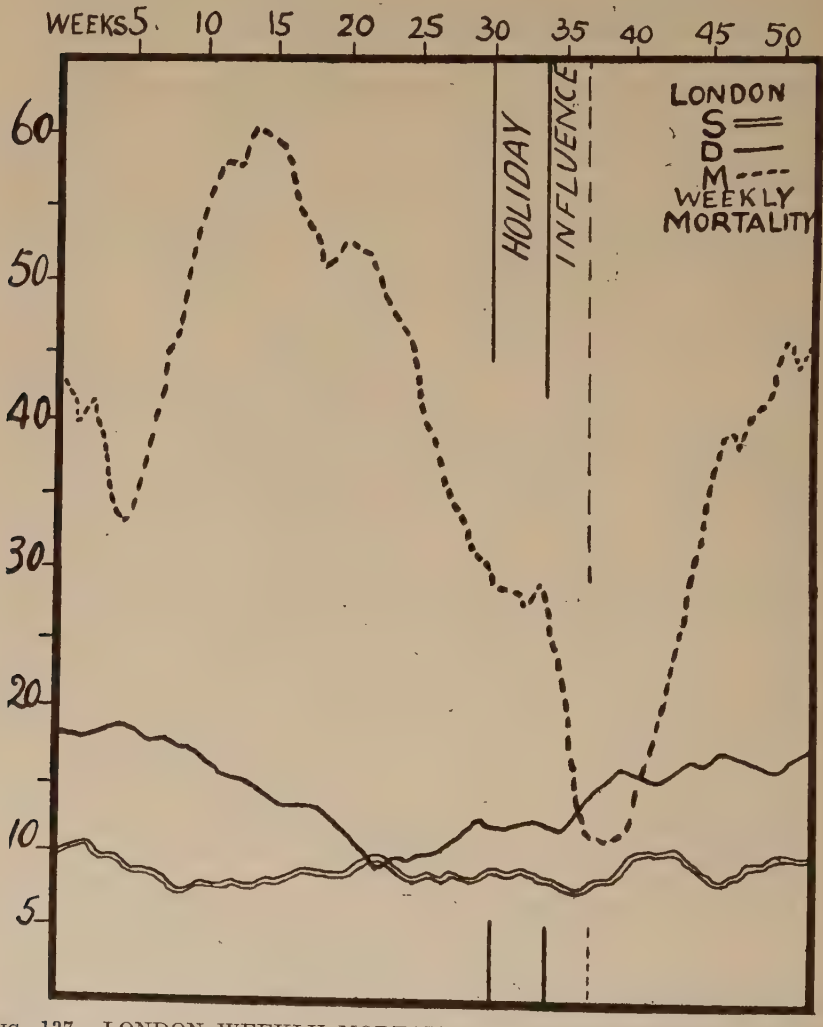


FIG. 137.—LONDON WEEKLY MORTALITY SUMMED FOR TEN YEARS.

therefore have played any considerable part in the dissemination of infection " (*L.C.C. M.O.H. Report*, 1923. 17).

Mortality curves for ten years in London (*M.O. Ed.*, 1911. 132) were also against the " holiday influence " as a suppressor of infection. (They are taken for the period of the Holiday Influence doctrine.)

The influence of the Education Acts in different decennia on scholars' mortality can be deduced from the reductions in death-

rates before and after school ages in boys and girls respectively (*Journ. Roy. Stat. Soc.*, 1897. 623). Girls' death-rates have been steadily lowered, and approximate more closely to boys' for zymotics. For phthisis this reduction does not shew. The general deduction is that school attendance *qua* disease is healthier than was the previous home condition. Even in such diseases as measles or influenza, the primary school is probably very much less important in urban districts than usually supposed. For country districts the material is insufficient to decide.

The maintained complete closure of all schools after a few months, when stability had been obtained, would probably make no appreciable difference in the zymotic death-rates (*L.C.C. M.O. Ed.*, 1911. 133), if it did not increase some.

School Closure.—The Committee of the American Medical Association and the (U.S.A.) Bureau of Education reported in 1919 that "the closure of schools is an extremely clumsy, unscientific, and unsatisfactory method of controlling epidemics among school children. It results not only in loss of school time and money, but it fails to control, inasmuch as infected children are at large, playing in the street without restriction, and therefore spreading the infection."

Closing of schools should only be considered as a last resort, and then only for sparsely populated places, where aggregation is mostly in school. Exclusion of contacts means freeing them to spread disease uncontrolled. Contacts are better in school so long as there is no evidence of danger from them. The danger is that potential cases are only supervised when in school.

The Board of Education have revised their school regulations for infectious diseases with some slight changes (1924), but gradings of schools are determined by average attendances, and on these also depend staffing numbers and salaries.

The old rule, known as 101*, of a quarter of a century ago, which allowed each child absent on medical grounds for infectious disease to be specially marked in the register, and counted as if in attendance, could not be surpassed. The code has been amended so that closure of a school in epidemic times need not be on financial grounds to prevent lowering of average attendance, but purely on medical grounds.

Non-epidemic times are more numerous, and human nature, whenever a school is anywhere near an average attendance boundary-line, will still seek its own profit and reward by securing the maximum attendance, even with convalescents. Under such conditions the Regulations for exclusion of infectious cases remain unsatisfactory, although not on the ground of infection so much as securing rest and recovery for sufferers.

The earliest possible notification is wanted for school action in regard to infectious diseases. The best service of all would be an

immediate visit from a school nurse for the purpose of preliminary diagnosis in any case where the parent does not send the child to school on account of illness. As yet such efficient action is not within the practical field, although being attempted in a few places.

Means of information, often considerably delayed, are cases coming to the Medical Officer of Health through notifications by head teachers to the Medical Officer. These may be by letter, verbally, or returned on an official form.

Notifications may be by School Attendance Officers, who visit the homes in case of absence, or hear casually on their rounds of illness. In infections they also notify the Medical Officer of Health on a form. They also usually make a weekly return of cases of sickness. The School Medical Inspectors or School Nurses meet cases in their work. Notifications in the statutory form are received from local doctors.

Exclusion of single cases, whether ambulant cases or contacts, is provided under Article 53 (*b*) of the Code, which provides for exclusion of individuals on the ground that this is desirable: (1) to prevent the spread of disease, (2) because their uncleanly or verminous condition is detrimental to others, (3) their health on account of physical or mental defect renders them incapable of receiving proper benefit from the instructions.

Where an official exclusion for a definite period is made for health reason, a triplicate form should be used, and a copy is (*a*) sent to Medical Officer, (*b*) kept at school, (*c*) retained in signatories' books. At the end of the period the child should be re-examined.

These infections occur in school ages, and hence occur in school children, but the cause is not the school. The carriers are often adults, but children are susceptible to the diseases, and suffer. Were this not so, school closure might be effective.

Where school closure is resorted to, and it is always unnecessary on account of disease, the school Medical Officer can do this under 45 (6) of the Code. The Sanitary Authority can also close a school under 57 of the Code, or Section 13 of the Statutory Rules (835 of 1925), for special services.

" In proportion as the school under present conditions recedes as a factor in disseminating disease, so from the public health point of view do other factors gain in importance. In future the sanitarian must not be hypnotized into regarding the school as a chief centre of disease, but must turn his attention to possibilities of preventing infection in families and houses, courts and streets. It is only when efficient measures are turned in these directions that he will gain a recompense proportioned to the cost of his efforts. Increased expenditure in the prevention of disease dissemination in schools would probably give a better result if directed into these other quarters " (*L.C.C. M.O. Ed.*, 1910. 69).

CHAPTER XXXVIII

CLEANLINESS

Cleanliness.—Personal cleanliness of pupils is one of the most powerful educational appeals, but indirect and therefore all the more effective, for promotion of self-respect and good living. Insistence on this appears to be strangely neglected by many teachers. Direct exhortation here is of comparatively little effect compared with cumulative effects of example, imitation, custom, and, finally, developed habit. The habit of cleanliness acquired in school ages will remain through life until mentality itself begins to dissolve.

Every school should have means of cleansing hands and face. The provision required by Regulations is two basins to 50 scholars in primary schools. For secondary schools it is one basin to each 20 boys up to 100, then one to every 25. For girls one basin to every 10 to 100, then one to every 20. This means for a department of 300 scholars, boys or girls, in a primary school 12 basins. In a secondary school, boys 13, and secondary girls 20.

Washhand basins may be there, but in many schools there are no available supplies of water, soap, or towels.

In the Report for 1920, of 373 Leeds schools, 95 were without such a primary necessity for children as drinking-water.

Provision of washing basins without a proper supply of water, and necessaries for washing, is an evasion of the spirit of the Regulations overlooked by Inspectors. Soap is commonly a cheap resin soap, with much alkali. It is too detergent. Outbreaks of dry, scaly patches on children's faces may testify to its powers. Proper soap powder can be supplied in wall boxes, either to be sprinkled out in a ration, or taken out through a hole in the box bottom with the finger (Cd. 8387. 1916).

The roller towel is prohibited in Kansas. It is known in our own schools as the chief medium for transmitting acute conjunctivitis—"pink eye." Paper towels are the rule in American and Canadian schools.

All washing arrangements should be separate from cloak-rooms, where clothes are often needed to be dried.

Baths.—There are two purposes for which baths are useful for school children. One is for cleaning purposes ; the other for educational and recreational purposes.

For cleansing as a sanitary function, the problem has to be reduced to simple factors. How little space, how little water, and how little heat is required.

For these purposes cleansing baths apart from swimming pools should be a requirement in every school of over 300 children. Co-operation in this matter is vastly cheaper to the country than scores of private baths in houses, many of which will be used as uncomfortable sleeping places. Hope in Liverpool, from extensive enquiries, found that of families of children returned as verminous in school, only 4 per cent. had a fixed bath in their home. A commentary on the work of the Local Education Authority in bathing unclean children in London is that as the parents found out about it, and began to send the children voluntarily for baths, regulations had to be altered to prevent them utilizing the cleansing scheme in this way (*M.O. L.C.C. Rep.*, 1913. 84).

Children require cleansing to prevent vermin, and school provision is the cheapest and most effective method of this general sanitary measure. A child would be better for a bath twice weekly, but one at least is the effective minimum.

The best arrangement is the shower- or douche-bath. Gottingen, on suggestion of Professor Flügge in 1885, instituted the first school shower-baths, and since then the arrangement has not only spread all over Germany, but run round the world. In Denmark, as in a few German towns, school baths or bathing are compulsory.

In a few places it has been attempted to utilize public baths, by restricting them for scholars' use, only at certain hours. The provision has never succeeded anywhere, either in cost or convenience, and is now generally condemned. The rate public provision in London is used is one bath per head annually. The question of school bathing has been evaded for nearly twenty years in London (*L.C.C. M.O. Report*, 1919. 28).

The proper arrangement is for cleansing all scholars. Teaching swimming to a proportion of them, as in London, in no way compensates for failure in the duty of cleansing. The douche is the best cleanser, as each child has his own water supply. German experience is that only a tenth of the water, a tenth of the heat, and a fifth of the time are required for cleansing. There is no long soaking of the skin, which is harmful to some. The baths can be kept clean more easily, and fatty deposit which forms on tub or tank baths is avoided. The douche heads should be about 4 ft. apart, and sufficiently high to be beyond the reach of children.

Bath-rooms and dressing-rooms can be fitted to utilize cellar space. Each bathing- or douche-room should be arranged to take twenty children. It is convenient to have dressing-rooms on each side of the douche-room, so that when one batch is dressing another can be getting ready. Convenient spaces must be arranged for

hanging clothes. Fear of vermin is no worse here than in the school-room.

Heating arrangements for the douches must be absolutely fool-proof. Water heated not above 120° F. is mixed with cold water, to fall from the showers at 95° F. ; after two or three minutes a further proportion of cold is added, gradually reducing the douche to 65° F., when it is stopped.

Children admitted to the douche-room should be allowed about a minute to soap themselves, about a minute full douche, then temperature should be slowly reduced. From entry to exit from the douche should not be five minutes, and from entry to exit to the baths not more than twenty minutes.

There is no legitimate reason for each child being required to be in a separate cubicle for bathing. The single douche-room is easily supervised, and prevents improper behaviour. Older girls might have some few cubicles at one end of the douche-room allotted to them. At Nuremberg separate cubicles are not popular, and even older girls do not like to use them.

We are getting past the false modesty which would rather be dirty than naked, or religious fetichism which teaches that the body is an unholy thing.

The quality of the school air is improved. The fœtid smell of an East End school would be much modified if every child were bathed once or twice weekly. Experience also shews that children's clothing is improved after a time.

The cooling effect of the douche at conclusion is stimulating and hardening. Most schools give no baths for forty minutes before school dismisses, so that there may be less risk of outside chill. Soap liquid in a box removable by the finger-tips and towels are provided by the school.

The douche-room itself should be tiled up to 4 ft., and corners rounded. A fairly non-conducting material is best for the floors. The floor of the dressing-rooms might be heated. In Germany they are generally covered with linoleum. The rooms should all be kept about 68° F.

Good ventilation and efficient drainage are essential. With the steam and heat of the bath, windows with hoppers at the top opening outwards are most effective.

Swimming-baths are more costly, and rather luxuries than necessities. The advantages of swimming both morally and physically give it considerable educational value. School swimming-baths should always be white tiled, to shew up dirt and to prevent accidents. Sterilization of bath water is important. The only definite evidence of disease conveyance by swimming-baths is that in some large residential schools where outbreaks of conjunctivitis were formerly common, they have practically ceased with the use

of copper sulphate in swimming-bath water in proportion of one to a million.

Standards adopted for many swimming pools of Detroit in 1924 were, a median bacterial count below 2000. Not over half the samples in any month should shew presence of colon organisms, and not over one-fifth a colon count above 10 per 100 c.c. An American Committee, which investigated this from the otorhinological standpoint, recently recommended that water should not shew more than 1000 colonies after 24 hours' incubation at body temperature (*J.A.M.A.*, 1925. ii. 356). It is probable that if the bathing load is kept down to 800 gallons to each bather the pool will remain in acceptable condition.

Dr. Forbes has made an investigation of the bacteriology of swimming-baths (*S.H.*, 1912. 79). He has shewn with impurities varying from 43 organisms per cubic centimetre to over 300,000 per cubic centimetre, according to the amount of use of the water, under various conditions, how skin, salivary, and intestinal infections may occur. An outbreak of conjunctivitis due to Koch-Week's bacillus was brought to an end by stopping use of the swimming-bath, but the organism itself he found apparently too delicate to recover from water. He reviewed the dangers later (*Lancet*, 1921. ii. 728).

For daily use in a school such refined methods are hardly necessary. Chemical disinfectants are quite reliable. Copper sulphate in proportion of one part to a million used in some school baths is satisfactory. For use on a large scale it would be rather costly, and has the disadvantage of discolouring tiles, and also makes water hazy. Chlorine gas as liquid is cheap and effective. Its odour is noticeable, and some complain of its nipping the eyes; in strength of one in a million.

Chloride of lime in proportion of $\frac{1}{2}$ lb. to 25,000 gallons, which would be a pool of $50 \times 14 \cdot 5$ ft., and average depth of $4 \cdot 6$ ft. This gives $2 \cdot 4$ per million chloride of lime, equivalent to $0 \cdot 8$ chlorine per million. The finely powdered material in a cheese cloth may be dragged about in the bath. Another way is a pound of commercial chloride of lime dissolved in 5 gallons of hot water and sprinkled from a watering-can.

Electrolytic solutions of sea-water are solutions of hypochlorite produced by electrolysis. Dr. F. W. Alexander has worked this out thoroughly, and it is produced artificially at Poplar at about a halfpenny a gallon. Thirty gallons are added to a bath of 85,000 gallons' capacity at its first filling, and then further additions, not more than three doses altogether, sprinkled over the water as required keep it in condition till it is refilled in about ten days. The fluid is stable, and in the amount used gives about 1 of chlorine to 2 million of water.

Whilst practically no children fit for the ordinary school are

unfit for the shower-bath, the class of children already noted as only to be exercised with caution should be considered unfit for the swimming-bath. The temperature is reduced, in a few as low as 95° F., after a prolonged stay of 30 to 40 minutes in a swimming-bath at 73° F. (*J.A.M.A.*, 1925. ii. 10).

The risks of infection or contagion from douche baths is practically negligible, whereas in swimming-baths there have been instances of seeming infections. Baginsky reported an outbreak of acute contagious ophthalmia through children using a bath in the West End of Berlin, and two years later an outbreak of granular ophthalmia from the same cause (*Zeit.*, 1900. 85). Many outbreaks of conjunctivitis, and sometimes of forms difficult to distinguish from trachoma, have been ascribed abroad to swimming-baths.

Croydon had a printed form prohibiting children with eye troubles from using public baths.

Reece (*L.G.B. Report*, 1908–9. 90) reported typhoid from the use of a swimming-bath, and several American cities warn bathers about typhoid from this source. Impetigo and streptococcal infections have been attributed to bathing suits. It is not clear that any of these diseases were really due to swimming-baths. Dr. Friend of Christ's Hospital thinks the use of cocoa-matting or carpets may help to maintain such disorders as tinea cruris.

Swimming-baths play an undoubted part in provoking otitis of various descriptions. Cheatle called attention to the crop of cases of acute otitis seen in hospital out-patient rooms with the beginning of every swimming season. High diving has been found particularly productive of trouble.

Fenton regards nasal trouble from sinusitis as the most frequent cause of infection of the ears from swimming. The otitis is due not to septic water, but to auto-infection. The bathing season is accompanied by frequent acute mastoid disease which may develop in a few hours after sea-bathing. He thinks that nasal plugs, and not ear plugs, are desirable if this is to be prevented (*Tr. Am. Oph. a Odont.*, 1922. 421).

The frequent relapse of old cases of otitis which were well, or of dry perforations which have begun discharging, or even acute otitis, or furunculosis of the external meatus provoked through swimming, is certainly common. The last is stated to be very common in Japanese children (*Z. f. S.*, 1913. 199).

Without thorough protection of the ears with cotton-wool plugs, and preferably waterproof ear-caps, the swimming-bath should be forbidden to scholars with any history of past otitis, with dry perforations, or with acute discharges ; with catarrhal deafness, or noises in the head. Those, too, who complain of itching of the ears may have dry perforations or eczematous conditions easily excited.

Ear troubles are found in higher than normal proportions among the children who excel in swimming or diving.

Vulvovaginitis should be mentioned, as Skutsch described 236 as being infected in a public swimming-bath at Jena in 1891, whilst boys using it escaped. An outbreak is also recorded by Suchard in Switzerland.

Verminous Conditions.—One of the first hygienic efforts in school was directed to the plague of lice in children's heads, *Pediculus humanus capitis*. The frequency of body lice, *P. h. corporis*, also became evident when the nurse followed the doctor into school. The third variety, *Phthirus pubis*, is rarely seen on eyelashes, or occasionally as a foreign body in the conjunctival sac.

The louse is an insect about a twelfth of an inch in length. It is not bred by dirt, nor does it live on garbage. It is purely a bloodsucker, and cannot survive long apart from a host. Frequent change of garments makes its life impossible. There is little difference between head and body varieties, the first is a trifle darker and smaller.

The nit in which the embryo develops for about a week is deposited on rough surfaces, especially seams on the under surfaces of clothes. The head louse fixes its nit on a hair near the scalp. It is a matter of a fraction of a minute till the nit is fixed. The louse ejects a small quantity of the chitinous cement substance which spreads round the hair. The nit is then ejected and sticks to this. The insect moves along the hair, leaving the nit adhering parallel to the hair axis, and with its widest end towards the free extremity of the hair. This end is covered by a lid, the operculum, which the young louse pushes off in escaping, leaving an empty shell. The nit, previously transparent and scarcely to be seen, now fills with air and may have a silvery grey appearance. Nits seen far out on the hair, which has grown a considerable length since they were fixed, are only important as indicating past infection and neglect for a considerable time. It is not the presence of the nit, but its persistence, that indicates disgraceful neglect.

The cement which seals the nit to the hair is very resistant, and cannot be dissolved. It may be softened by hot acetic acid of 10 per cent. strength, and then nits can be scraped off the hair, using either a very fine metal toothed comb or sand-paper. The main remedy for louse destruction is paraffin. This may be rather irritating in use, and paraffin and sweet oil in equal parts is more effective. The head is well rubbed with the mixture, then swathed in a towel, or india-rubber cap, and left for eight hours. After this, shampoo with two quarts of hot water in which a small quantity of carbonate of soda has been dissolved, soap well, and wash out.

Tincture of larkspur has been recommended, or oil of sassafras

as being more elegant. Some teachers object to the smell of sassafras, and it otherwise has no particular advantage.

London instructions are to clean hair well with paraffin. Nits can then be removed by shampooing with a lather composed of one ounce of powdered borax and half a pound of soft soap in a quart of hot water. Well rubbed with lather for five minutes, adhesion of the nits is loosened, and the fine comb removes them easily at one cleansing.

Moore and Hirschfelder, of Minnesota University, have recommended heliotropin as the best pediculicide. It has an agreeable

FIG. 138.—NIT ON HAIR, MAGNIFIED ABOUT 50 DIAMETERS.

vanilla-like odour, and can be made up in various forms as a 5 per cent. strength for application to the head.

Corlette uses a solution of heliotropin 5, castor oil 30, pure methylated spirit to 100. This gives an elegant preparation for children. Spirit may be left out if the lotion is to be uninflammable (*Med. J. of Austral.*, 1925. i. 185).

Little attention was formerly paid to physical condition of children. Almost every class had one or two children suffering badly. The occipital region of the scalp was often covered with matted hair, and evil-smelling crusts and exudation, infected with lice. Septic inflammation, swollen posterior cervical lymphatic glands, and sometimes suppuration and sinuses resulted.

The immediate demonstration of need for improvement unfortunately side-switched the whole educational aspect, and only left the nuisance evident, so that at enormous expense a steady fight has gone on to keep down the evil, which begins again the moment effort is relaxed.

It is an affair of the family. Year by year children from the

same families offend. Dr. John Priestly stated the problem some years ago. "There are 55 per cent. of parents who keep their families free, although every tenth boy and every second girl in the schools is a risk of spreading infection. Thirty-five per cent. only partly succeed, and 10 per cent. are hopelessly bad."

Sobel, in New York, defined head lice as an index of family cleanliness. Hope of Liverpool, reviewing the work of health visitors, put down overcrowding as the cause. Fifty-eight per cent. of the children affected were sleeping three or four in a bed, and 4 per cent. five or six in a bed. He thought 50 per cent. of the parents to be doing their best under the conditions, and in 9 per cent. the mothers were dead or invalided.

Bacot, who was fatally infected by lice when investigating typhus fever, with all his comprehensive knowledge, stated poverty as the root cause in civil life, and that pediculosis always depends for continuance on low standards of life (*S.H.*, 1919. 34).

The hopelessness of solving the problem by school means had already been indicated. The clauses of the L.C.C. Act of 1907, drawn up without reference to the workers in schools, set the process of handling uncleanliness on the wrong lines. The only effective school method is education, not punishment.

Years later some glimmer of this came to Care Committee members, who, noticing that adults often infected children, thought advice should go to the homes, and actually suggested that "this is eminently work for which members of the Care Committee are often more especially fitted" (*L.C.C. M.O.H. Report*, 1914. 42).

Watching children in their fixed places in classes in Breslau, Moritz Cohn (*Z.*, 1911. 145) determined that class infections were almost negligible, even when a child was sitting for weeks with infected children all round it. Infected children cleansed soon became reinfected, and home influences, or at any rate out-of-class influences, were evident, as clean children did not get infected.

Dr. Vercoe, in Colchester, noticed that if a class is arranged in order of cleanliness there is no extension of the trouble. He does not seem to have appreciated that this is evidence of home influence, and not of diminished school infection (1919).

Before there were any statutory powers *ad hoc*, the method of dealing with cases of uncleanliness which the writer adopted was an indirect device. The child, having been examined so that the condition was incontestable, was then excluded. The parents were now summoned for its non-attendance, and generally fined. The power can still be used in certain cases, although for verminous conditions the Children Act is the main method of procedure.

The Children Act, 1908, Part II, Section 12, deals with cruelty or unnecessary suffering or injury to children, and neglect of children. This is defined as "if he fails to provide adequate food, clothing,

medical aid or lodging." Section 122 of the same Act has now been incorporated in the Education Act, 1921, as Section 87. (1) Confers power on the L.E.A. to direct their Medical Officer, or any person with his authority in writing, to examine the person or clothing of any child attending a public elementary school and if he thinks necessary he can give written notice with the necessary instructions, requiring the parent to cleanse the child in 24 hours; failing this (2) the child may be removed from the school to suitable premises to be cleansed. (3) Confers power of Sanitary Authorities and L.E.A.'s to make arrangements for use of premises or appliances for cleansing; and (4) renders the parent liable to a fine of 10s. if the proceedings have to be renewed. (5) Orders that girls are only to be dealt with by a medical practitioner or duly instructed woman.

The standard of cleanliness is very high. Dr. A. H. Hogarth drew up a classification for an enquiry in Buckinghamshire before the War.

1. Clean.
2. Nearly clean, nits not more than a dozen.
3. Nits counted by tens.
4. Few nits and lice.
5. Nits counted by hundreds.
6. Many nits and lice.
7. A dirty neglected child to report to N.S.P.C.C.

He pointed out the futility of most statistics, and the benefit of reports of court cases in the local county papers (*S.H.*, 1917). The writer has frequently seen children whom he would have regarded as clean, till the nurse has demonstrated nits. The drawing was made from a hair excised in one such case (Fig. 138).

In one case where the doctor and nurse had passed twenty boys for a camp school, the twenty were then referred to an assistant superintendent of nurses, who examined them in a separate room. Using a lens, she detected nits in six of them, mostly under scurf, but two shewed the actual louse emerging (*L.C.C. Report*, 1920. 21). The writer has known 25 per cent. of girls in a secondary school returned as unsatisfactory, and on applying cleansing schemes in secondary schools, 489 of 3440, or 14·2 per cent., had to be given warning cards. The condition would not now be found.

The amount of work done by the school nurses is enormous. In 1924, although the average annual number of visits per school by the nurse is only six, there were 2,059,590 rota examinations in London.

Of these 16·1 per cent., or 332,659, were noted as verminous. Nearly a quarter, 74,643, were referred to cleansing stations, but 22,012 were subsequently cleansed by their parents.

Cleansing stations dealt with 52,631 verminous, and 2155 scabies

cases, and an additional 23,986 were dealt with at head cleansing centres. Of cases cleansed at stations, 34,963 attended voluntarily for treatment, but in 20,739 cases a statutory notice had to be served. There were prosecutions in 805 cases.

The effect on the body vermin has been extraordinary. They have practically disappeared. Only 84 cases were noted in 1924. The older girls, who a dozen years ago had only 67 per cent. free from head vermin, now (1924) have reached 82·5 percentage clean.

It would be interesting to know the seasonal variations of head infection.

With the children noted as unclean or verminous the parents have to be informed ere further action is taken. A notice is usually sent in a sealed envelope. It states conditions and suggests remedies. When bathing stations or cleansing places are provided, arrangements for their use may be suggested. If the child is not treated in some way, a statutory notice has to be served at home. Again offers of voluntary cleansing can be repeated, but if after a definite period, of a week or ten days, insufficient action has followed, compulsory cleansing can be done, and if necessary any hair with nits cut off. It is usual to keep in touch with the Sanitary Department, so that the home may come under purview as well.

There have now been numerous convictions under these laws. In Walker *v.* Cummings in the K.B. Div. of High Court, May 17, 1912, the child had been excluded. It was presented at school, but refused as unclean, and the Andover Justices refused to convict, holding that presentation at school was not non-attendance. The L.C.J. held that respondent knew the condition of child, and did not cure it, and knew that the refusal was on account of its verminous condition, and that the Justices should have convicted. It has also been held, January 25, 1922, in K.B. Div. of High Court on appeal, that Section 122 compels the child to be submitted to inspection. The magistrates have also decided that on leaving the bathing place the child must be free from any trace of vermin, and for this it may be necessary to cut the hair. The cropping of the hair in the past has been the cause of much trouble. In one case a riot occurred in South London which necessitated the closure of the Cleansing Station for some time. Methods are now used which make hair-cutting unnecessary.

When a child becomes verminous again after having been cleansed, the usual proceeding is to forthwith exclude it, and take police-court proceedings.

Scabies.—Scabies, or the itch, is an accompaniment of the neglected or needy in the lowest social depths, due to infection by a mite. This has long been known. Dr. Johnson mentions it in his Dictionary in 1755. *Sarcoptes scabiei* is about a fiftieth of an inch in length. It is a trouble which anyone working in schools

may contract, but it is rare apart from members of a few families. The diagnosis may be difficult, although a general facies is common, in much worn-out old clothes, poverty-stricken debilitated appearance, and general air of indifferent endurance.

Itching, worse at night, is the leading feature. Marks of scratching and irritation about back, shoulders, and joints are suspicious. In children, evidence is looked for in vesicles between fingers or on wrists. There may even be some impetiginous sores. With a lens burrows may be found, and occasionally, even the acarus itself turned out by the point of a needle. A diagnosis is not likely to need settling by catching the cause. Others in the patient's family are likely to be affected. In summer the little hard papules of dysidrosis may give rise to a suspicion of itch. They are usually found about the palms as well as between the fingers, and burrows cannot be found.

The sheet anchor of treatment is cleansing with hot baths, and use of sulphur as an application. Clothes and bedding of patients should be sterilized with superheated steam. Cleansing of a child by the L.E.A. or Sanitary Authority may often be futile, from well-established infection in the home.

An artisan home does not lend itself to drastic bathing and sulphur treatment often required, so that a treatment centre is needed for most cases. The usual treatment for a single patient would be frequent hot soap and water baths, with thorough scrubbing, drying, and inunction of sulphur ointment, diluted to about 1 in 12, or 15; or a less irritating mixture would be,

Balsam of Peru.
Soft soap.
Zinc oxide.
Prepared calamine āā 2,
Petrolatum ad 30.

This repeated for three or four days as an application to all affected parts.

With prolonged treatment, or too strong sulphur preparations, the child may well be cured of itch, but develop a sulphur dermatitis. Patches of dermatitis are formed in unusual places for itch, and dermatitis may be suspected where there has been thorough treatment.

The itching at night has usually disappeared. The treatment is some soothing application to the skin; calamine lotion and so on, and omission of any sulphur.

Sundry Norwegian or Danish treatments, depending on mixtures with sulphur in easily decomposable compounds, such as sulphides of the alkalies are recommended. Reactions with the skin moisture liberates small quantities of sulphuretted hydrogen, and the mite is poisoned.

Dr. Brown Ritchie, in Manchester, thinks that the Danish treatment has reduced the proportion of cases there by a third. Each Medical Officer will have to work out his own technique, depending on arrangements at disposal and number of cases. Families in a district which continue infected with scabies almost give an index of social or sanitary inefficiency. Probably where there is much infection drastic treatment by removal of the whole family to a treatment centre, and moist heat disinfection of all clothes and bedding, will be best, but this is a matter for attention of the Local Sanitary Authority.

The harvest bug has to be remembered when a question of possible itch arises in children's legs. It may be contracted through playing in long grass, in dry sandy places especially. It is due to a small mite. Washing with methylated spirit or with a 5 per cent. carbolic lotion will give relief.

Round Worms.—The infestation of children by ascarides is very common in some country districts. Various nervous symptoms may be due to these. Dr. A. H. Hogarth thought they were associated with low-lying, damp regions in Buckinghamshire, where the material from earth closets was used on cottage gardens. There have been no enquiries, so far, on this subject.

Wood Tick Paralysis.—Although not met in Europe, there is an ascending flaccid paralysis occasionally seen in school children in parts of the United States, British Columbia, and Eastern Australia, due to bites of the wood tick, *Dermacentor venustus*.

Paralysis is acute, and may cause respiratory failure. Recovery is rapid and complete on removal of the tick. The insect is found on the scalp, back, or axillæ in children. The head of it has to be removed by gentle traction, or the application of kerosene or chloroform. The Australian form is due to *Ixodes holocyclus*. Its onset has been taken for infantile palsy. In one case, which was fatal in a girl of 13, the tick was attached to the membrana tympani. Apart from the troubles already described, there are certain other conditions of the head likely to come under notice. These may be grouped as alopecia areata, favus, and varieties of ringworm.

Alopecia Areata appears as sundry large, bald patches on a child's head. The skin of the patch is thin, white and shiny, giving the impression of atrophy. Some fine hairs about the edge are found to be withered and atrophic, with a tendency to bulbous ends. There is no obvious fungus present. It is decidedly uncommon, and is not contagious. As a rule the child is in a debilitated and nervous condition, and if rest and a change can be obtained would be better either away from school altogether for a month or more, or else transferred to an open-air school.

Attacks of Impetigo may be cured and five or six weeks later patches of hairlessness appear which suggest alopecia. It has to be

differentiated also from some forms of ringworm. When a boy has his hair cropped short, numerous small bare spots, the result of old injury or sores, may cause a teacher to suspect ringworm.

Favus consists in an eruption which becomes crusted over, and finally forms a mass of exudation with secretion below it, the favus cup. It is due to a fungus, which was the first parasitic scalp fungus demonstrated, in 1839, and called *Achorion Schonleinii*, after its discoverer. The disease was described by the Viennese dermatologist Gruby in 1841, and has been well known since. The spores effect a landing on the scalp. They may rarely infect other parts, as the shoulders or back. Then probably they are a special variety such as mouse favus.

The easiest point of invasion seems to be about the orifice of sebaceous glands; then spreading out between corneal layer and stratum lucidum, they send long mycelial threads up into hairs. There is seen a little redness, and crusting on the skin around an infected hair. The flexibility and smoothness of the hair is lessened. It can be pulled out easily. Such a hair is placed on a glass slide, washed for a moment or two with ether or chloroform, allowed a few seconds to dry, and then rapidly mounted in Canada balsam. Under a magnification of 200 to 300 diameters, a number of dark rods are seen running axially in the hair, and occasionally dichotomizing. They are favus tubules; the balsam has not penetrated them, and they remain filled with air, and shew up clearly. If some of the material from the crusts, or under them, is examined, teased, in a little weak potash, it is seen to be made up of mycelium and spores, "like knucklebones." These are quite characteristic, and cannot be confused with any variety of ringworm. With Gram's stain they come out brilliantly.

If the case is further advanced, the vesicles coalesce, and a small crusted mass with some hairs penetrating it is formed. This is the beginning of the favus cup. Underneath it is a yellow honey-like mass of fungus and exudation. On breaking it up, a mousey odour is detected, although this was not always so at the favus school.

It was established in the favus school that the risk of infection in school was almost negligible. Dust taken from various parts of the school always failed to give cultures, although they were readily obtained from hairs or scales from children's heads.

Favus is not very contagious. It chiefly affects patients in reduced health. Once established, it may persist in the most stubborn way. Many people seem immune. Saboraud quotes a woman who lived with an afflicted husband for fourteen years, but never contracted it. The writer watched a small Jew boy in a school of a thousand children. He was the only case in the district During two and a half years that he was under observation no other case occurred, although no special precautions were taken.

Epidemics are almost unknown. It is said that favus in Paris does not amount to more than 8 to 10 per cent. of the tineas, whilst in the country, as at Rennes, it may run between 50 and 65 per cent. of those seen. It is uncommon in this country, and London cases are mainly in alien families.

The favus school formerly established in Whitechapel cleared up over one hundred cases in two to three years, by assiduous attention to cleanliness, and ultimately use of radiotherapy, this principle of dealing with favus being the same as for ringworm.

The Edinburgh favus school had forty cases in its opening year, 1912, but new cases have fallen to under ten a year. There are several other varieties of favus, distinguished easily by cultures, but they are uncommon on the head.

Ringworm presents three clear varieties, and these can be subdivided still further by cultures. For practical purposes the small-spored ringworm due to *Microsporon audouini* is the common variety in England. *Tinea tonsurans* is rare in some places. In Berlin an outbreak appeared as a novelty in 1907; by intensive treatment it was conquered in a few months at a cost of about £35 a head (*S.H.*, 1910. 41). It is very contagious. The hairs are not penetrated, but eroded. It spreads over the surface of the hair. They are seen on a bald patch of silvery grey, scaly surface which may be the size of a half-crown, or little patches may be found scattered about the scalp from which short stumps can easily be plucked with the finger and thumb-nail.

The broken-off stump often shews a white collar. If laid on a glass side, and chloroform or ether dropped on it, the hair goes opaque and white. If mounted in a 1 per cent. potash solution, the hair is seen eroded and encased in a layer of small spherical spores. The disease tends to relapse, is very difficult to cure, and generally disappears spontaneously at puberty. The large-spored ringworm *Trichophyton tonsurans* presents two varieties, an ectothrix which does not penetrate the hair, and an endothrix.

It has large, square spores, and they look like a ladder when a piece is seen under the microscope. There are several varieties obvious when one is handling many children. The different varieties shew up well when stained. A saturated solution of polychrome methylene blue in 4 per cent. borax solution is allowed to stand 24 hours, and then filtered. This is the Bleu de Sahli, and stains these fungi well. The material has grease removed with chloroform, then wash with distilled water, stain one minute, wash, dehydrate, and mount in balsam.

The endothrix shews small bald patches, with broken-off stumps level with the surface. It forms so-called black-dot ringworms. When a stump is epilated it is thick and often curled. They do not have the white sheath seen in microsporon. This variety is

very resistant, and often remains for a year or two after puberty, but in the end vanishes without a trace. Ectothrix appears of a more inflammatory nature, frequently with pus formation. Of 2343 successive laboratory diagnoses of ringworm we found 76 large-spored varieties, 3·2 per cent. Scurfiness of the head in a school child may be taken to be chronic microsporon ringworm, till the contrary is determined.

All these fungi restrict themselves to the horny layer, and do not infect other tissues, although there is some general reaction of the body as a certain degree of immunity can be acquired, and antibodies exist producing a positive skin reaction.

Mode of spread, methods of infection, recurrence, and biochemistry of ringworm are subjects worth great attention, not for any great improvement in public health that disappearance of ringworm could effect, but for the way in which disease transference and maintenance might be followed out. It is supposed to be highly infectious, and school the main cause, which, considering the reduction going on, seems very doubtful. "A case of chronic ringworm has recently been found which had been in a large residential school for months without any other child being affected" (*L.C.C. Report*, 1908. 37).

The London nurse's diagnosis of ringworm was singularly accurate, only 3 per cent. of several hundred cases not being confirmed by microscopical examination in the laboratory. Medical certificates of freedom from infection were given almost recklessly in chronic cases. For years cases were being examined and detected by nurses. Thousands of children were out of school always from ringworm. It was estimated that it accounted for one-ninth of absences.

Until actual treatment by Public Authority was undertaken no impression was made. Nurses found over 100 cases a week, year in year out, and "a considerable amount of misdirected energy is being applied owing to ringworm cases not being followed up to the inevitable conclusion of a cure" (1909).

The effect of public provision for treatment here, and uselessness of hospitals in London until it was provided, can be demonstrated in the work of five years succeeding imposition of duty of treatment by the Education Act of 1918, as recorded by the Medical Officer (*Report*, 1924. 101). Were this treatment made wholly free instead of payments being required, the disappearance would probably be quicker.

Various methods of treatment in the past for both favus and ringworm were unsatisfactory, as materials used did not reach spores in the hair, or depths of the hair follicles. It was possible by epilation, which was painful and time consuming, to cure private patients. Treatment generally necessitated a thorough cleansing

from sebaceous matters, with spirit and ether lotions, then use of some penetrating materials such as iodine.

Slight cases being of but scanty import, it may be sought only to prevent the spread. Where X-rays are not used, many other methods are available, and in many cases give fair results.

Dr. J. T. C. Nash recommends an excellent method for preventing spread by use of greasy antiseptic ointment to load the spores, and use of a cotton cap in school. For small schools in country districts this is probably as useful as any method.

In Colchester, collosol iodine oil 3 per cent. strength is well rubbed in twice a day, the affected parts being daily washed with soapy water to cleanse away detritus.

At Blackburn, after shaving affected parts and washing off fatty matters, a lotion is dabbed on. It is made by stirring 5 grains

Table 97.

Year.	Fresh Cases.	Percentage Healed by X-Rays.	Outstanding Cases.
1920	3983	?	1332
1921	3473	60	999
1922	2766	65	818
1923	2322	69	705
1924	1724	70	482

of calomel into a dram of tincture of iodine, and obviously contains freshly prepared red iodide of mercury; lint is applied and bandaged on; next day it is again washed and treated, and the white precipitate ointment (B.P.) applied. The child is usually cured in a fortnight.

At Leeds, antiseptic soap spirit is used for cleansing, then the affected part swabbed with petrol, and strong liq. ferri perchloride dabbed on. This is done daily for three days, then every other day for three times, then once a week for three weeks. An old linen cap is worn, and the child attends school.

Where X-rays are not available, any of these methods could be used in school by school nurses. Due care will have to be taken in using green soap spirit lotion, which is inflammable.

The most satisfactory method, especially for favus, is epilation by means of X-rays, then antiseptic treatment until all hair has fallen. Treatment of the whole scalp is advisable.

The treatment was first used about 1902, but was unreliable until Saborand introduced pastille dosage in 1905. In earlier days considerable permanent damage occasionally was done by over doses, and bald patches were left. The success of the method

depends on subsequent prevention of reinfection. The whole proceeding is purely a matter of technique and experience, and no useful purpose would be served by detailing the apparatus, and its method of use here. The hair falls at the end of a fortnight, and should be destroyed at once, as it is infective. The child may resume school as soon as epilation is complete, and hair should have completely re-grown in three months.

As regards children with ringworm, parents are under the same law as for verminous children. Where a child was to be allowed to attend school, if the hair was cut and an ointment and cap used, in consequence of refusal of this treatment when prosecuted, the Aylsham Bench imposed a fine (March 1916).

At Newport, the parent refused to send two children, who were under treatment by the family doctor to any other than the ordinary school. The L.E.A. had provided a ringworm class $1\frac{1}{4}$ miles from their residence. After several adjournments the Bench imposed a fine, and made an order for attendance (*S.M.O., Newport, Report*, 1914).

When ringworm is prevalent, dermatitis also seems common. In country districts local forms may occur, probably due to infection by animals; there is generally a considerable inflammatory reaction and spontaneous cure.

Impetigo Contagiosa is another of the commonest skin troubles which anyone working in schools may easily contract. The superficial, raised, moist crusts, is coloured by the tinge of changing blood pigments, and surrounded by a narrow edge of inflamed surface. There may be superficial thin flat blebs elsewhere, the commencement of a fresh disturbance. They generally occur about the face. The angles of the mouth, the nostrils, and the ears are favourite spots. The staphylococci of the skin are the usual offenders. Occasionally streptococci also invade the vulnerable spots, and then are likely to be resistant, and there is always the danger of deeper extension in subcutaneous planes with phlegmon formation and acute septic illness. This is especially to be feared about the scalp. Either the dilute ointment of nitrate of mercury or white precipitate ointment has a rapid effect in the majority of cases. The most certain remedy is a 5 per cent. solution of gentian violet in 20 per cent. alcohol. After thoroughly soaking this in, some boracic or other soothing ointment can be applied to prevent scab forming. All cases, however, require treatment, as it is very infectious. One training college had four-fifths of its members attacked in a short time.

Seborrhœic Eczema.—Many poorly nourished children develop numerous rounded, dry, scaly patches of skin, the size of a shilling or larger, on their faces. The edge is sharply marked, and scaliness shews a tendency to linear cracking due to movements of the facial

muscles. It becomes so prevalent that one thinks of contagion, but it is not contagious like impetigo. Attempts to cultivate organisms from the surface have been fruitless. Dr. Ettie Sayer, who spent some time over the subject, found a weak solution of hyposulphite of soda a useful remedy. It was held to be due to a combination of climate, food deficient in vital qualities (vitamins), and possibly use of coarse resin soaps. Fortunately, no bad effects have been known to result, and cases recover spontaneously.

Dysidrosis, the eczema of fingers and toes, eczema marginatum, and other varieties in unhealthy individuals are really due to various forms of fungi, and react to antiseptics like boric acid or iodine.

Tinea Cruris is a very real trouble in residential schools. It has become more common since the War.

The fungi to which it is due are not so readily demonstrable as in ringworm. It seems to require a special condition of heat and moisture to enable it to exist, and then is very persistent. Its prevalence is chiefly among active boys who perspire a good deal, and whose garments are not washed, aired, or disinfected sufficiently.

The parts affected are most frequently the folds of the groin, sometimes the axillæ or internatal folds, and occasionally between the toes. Boys should be instructed to report any case of redness of the skin, and at the beginning of each term should be inspected. An ointment of benzoic and salicylic acids, of each 15 grains to the ounce, gives some relief. As a means of prevention, they should wear pants under cloth garments, and should have bathing drawers under shorts.

O.T.C. or other uniforms should be disinfected before transfer to others. Owing to the tenacity and liability to relapse, a case in a residential school should be confined to bed or bedroom. Thickly applied Ung. Chyrsarobini B.P. or Ung. Ararobæ B.P. is to be applied daily, and kept in place by bandages for six days. The skin at the end of this time should be smooth and pale, with a red erythematous line around the edge of the affected part. The boy might now have a hot bath, and be well scrubbed with soap, and put into clean clothes. As a precaution Ung. Ac. Benzoiei B.P.C. should be inuncted daily for two or three weeks, and the boy kept under inspection for fear of relapse. Disinfection must be strictly used for clothing, bedding, and towels. Desquamation between the toes should be treated with plenty of powdered boracic acid in the socks. If it persists, then the strong iodine tincture should be applied.

CHAPTER XXXIX

SITES AND BUILDINGS

Plans of proposed sites and school buildings should never be finally approved without the signature of the Medical Officer's examination and approval. Medical Officers are not infallible in school matters ; indeed, in recent years there is an example of a treatise on school hygiene by a leading Medical Officer of Health, the frontispiece being a school plan including class-rooms for 90 children and 130 children. Still it is important that the Medical Officer should always be consulted on proposed sites. Many years ago the writer was asked to report on a site the position and cost of which had been approved as suitable by the Technical Officers. After his report was submitted the site was offered to and accepted by the authority at half its previous price, a saving of thousands of pounds.

The selection of a particular site sometimes turns on considerations apart from sanitary or educational preferences. Whilst instruction and recreation with the minimum of fatigue and strain are the main purposes of school, the initial cost and upkeep are also serious matters. In large towns, land may be cheap in the neighbourhood of railways, canals, foundries, sawmills and so on, but these again may have educational disadvantages. Narrow, dusty and noisy streets may also be too near.

According to the Board of Education Regulations (Cd. 7516, 1914), the site for an elementary school should amount to a quarter of an acre for every 200 children, or 54 sq. ft. per head. Playing fields do not appear to be required, but where there is no other provision for outdoor organized games, a greater extent of playground space is ordained.

Play is to-day a larger school problem than it ever was. In large towns this provision for outdoor games elsewhere exists in practice mainly on paper, yet it should be a live reality in every child's daily life. A quarter of a century ago the writer suggested that side streets might be utilized by prohibiting wheeled traffic for certain hours, and this now is the practice in some American cities such as Minneapolis. The State of Delaware prescribes : "For a one-room school there shall be not less than 2 acres, for a two-room school not less than 3 acres, and for a three- or four-room school not less than 4 acres."

In schools of less than 200 children the playground space must be 2000 sq. ft. and 20 sq. ft. per head for older, 6 sq. ft. for younger children. If there are over 200 children, these last amounts must be 30 and 16 sq. ft. respectively. This rule is hard on schools of 150 to 200, giving between 33 and 30 sq. ft. per head. At 200 it rises to 40 sq. ft. and goes slowly down to 34 sq. ft. for a 500 school. The U.S.A. Bureau of Education Bulletin 1921, No. 45, states: "There has been a good deal of discussion of the London requirement of 30 sq. ft. of playground for each child, but this is an absurdly small amount."

When there is provision for organized games (a very indefinite statement) the same rules hold except that for older children 10 sq. ft. per head in smaller and 20 sq. ft. per head in larger schools are required for the playgrounds.

In secondary schools, on the other hand, "Playing fields must in all cases be provided, at least 2 acres per 100 children." Playgrounds have to be at least 750 sq. yd., and must give a minimum clear space of 50 sq. ft. per head.

In England sanitary considerations can scarcely be the cause of the secondary school child being provided with nearly double the air space allowed the elementary scholar. Not only are all hygienic accessories and amenities desirable, but they must be demanded. What is necessary in the one case is necessary in the other. The elementary scholar suffered through the want of accessible playing grounds.

The school must be made as wholesome and sanitary as the home. Realization of this truth will only come when every child of the community is compelled for half a dozen years of its life to take its place in the public school, no other schooling being permitted before the age of eleven. This is a *sine qua non* of healthy democratic schools, and since the War has actually been made a State provision in Germany (*Einheit Schule*).

The ideal of healthy schools was placed in the forefront of their programme by the Joint Committee of the National Education Association and the American Medical Association, and is the only school ideal worthy of a great or moral nation.

The conditions of the school, however, are different from those of a dwelling-house. Its purpose has to be remembered. The author has always insisted that sunshine is out of place in a class-room. Investigation shows that sunlight loses its vitalizing effects after passage through window-glass. Such sunshine has only the health-giving appearance, but is denatured and devitalized by the window-glass. The effort to get a sunlit class-room, however, generally results in ample measure of ventilation and natural lighting, the two desiderata of a class-room, so that indirectly the sunshine fetich has good effect, and in a class-room planned for

exposure to sunshine, window-blinds can always be provided to keep it out. "A site open to the sun is especially valuable to the children," says the regulation, but if sunshine is to be valuable, it must be in the playground, not in the school-room. Constant, even lighting inside is to be looked for, and a site in the proximity of high buildings, or with much of the eastern horizon blocked out, should be very critically examined. Wind, dust, proximity to noisy or offensive trades, may reduce the school value of the site, but such defects have often to be carefully sought out or definitely remedied before it is too late.

The condition of the soil is rather a matter for the architect or builder. Former ideas about ground air may be left out of account. A damp-proof course is a necessity, if things are not to rust and mould, walls sweat, and furniture crack. A damp or, worse, a waterlogged area should be avoided. One German writer with unconscious humour puts it that "Where frogs can be heard to croak is not suitable for most children." The neighbourhood of canals, marshes, and ponds, or stables or manure-heaps, may cause trouble from flies in summer, sometimes amounting to a veritable plague.

School as a Centre.—Transport and readiness of access from all directions must be considered. A case is reported where a fire-engine could not get to a school from the narrow access between houses. Freedom from close proximity to heavy bus traffic, or crossings with converging traffic, is important. Abundance of room is wanted, as schools, especially in the country, may be expected to develop. The increasing spread of education, and the diffusion of the knowledge and feeling that each person is a centre of some importance, with innumerable connections in the vast organism of the community, make it almost certain that the next quarter-century will see a considerable evolution of the school as an adult and a community centre. For this reason, then, as well as for educational developments and unforeseen extensions, in planning schools, sites should be got as large as possible—at least $7\frac{1}{2}$ sq. yd. per head in towns and 10 yd. in the country; but again these are to be taken as minima, and may be safely doubled. Australian schools, which a few years ago could easily have had large playgrounds, now often deplore the impossibility of getting sufficient room. Experience in London has shown that nearly every school built requires enlargement in a few years. It is, therefore, quite impossible to prescribe an optimum size for school site or for playgrounds; as large as possible is best.

In travelling through Germany before the War, the approach to most towns was heralded by a big new school in a wide yard, the outskirts affording the site needed.

Not more than one-fifth of the site space should be covered by

building. Here, again, the American ideal is a tocsin for authorities: "No community should rest satisfied with the minimum."

The value of playgrounds is so great physically and educationally that Education Authorities should maintain many playgrounds apart from schools.

Such provision as gas, electricity, water, and drainage in country places may make serious differences in the educational value of sites.

The Education Authority should be empowered to take land for public purposes; compensation for compulsory purchase being based on the average rateable value of the previous ten years. This is a most urgent reform for public protection and social advance, and, as regards schools, necessary if proper sites are to be obtained in England.

The school should stand back from its boundaries, being well isolated from shadows and noise. The English Board of Education requires block plans as well as details of buildings to be submitted for approval. The age of a school can often be surmised from this plan.

School Plans.—The original schools were long, barn-like buildings in which many classes were held side by side. Then frequently a stepped gallery was added at one end, or a short side-branch as in many mediæval halls, so that an L-shape plan afforded room for a separate class from the main hall. Old village schools were of this type. In towns voluntary schools run by religious communities often demonstrated that whilst cleanliness is next to godliness, it has nothing to do with it. Many of these schools were in dark, low-ceiled rooms under chapels. Fortunately, they have mostly ceased to exist in the past twenty years, and "teachers' laryngitis" has correspondingly vanished.

With the commencement of public education in 1870, the School Boards followed the Prussian system of grouping a number of class-rooms round a corridor. Some were round a central hall at first, but this hinders ventilation, and was abandoned for the corridor. Then the middle part of the corridor was expanded till it became a hall. This is the groundwork of the present-day style of town school, which is a kind of compromise between the corridor and central hall plan, combining both advantages.

This hall, although the provision was long resisted by the Central Authority, is a necessity as a place of assembly, and for many common school purposes. It has a psychological benefit in fostering an esprit de corps, and is useful for class exercises not permitted by the overcrowding in the class-rooms. The trouble is that where it is central either very costly mechanical ventilation has to be adopted, or the rooms have insufficient air change. The assembly hall for elementary schools is allowed $3\frac{1}{2}$ sq. ft. per head, which is insufficient for any assembly of the whole school. It would allow

no space for gangways. The minimum provision should be the 6 sq. ft. allowed in secondary schools.

In the case of secondary schools isolated halls to avoid dust, noise and disturbance from the class-rooms have been held to be very desirable by the Board of Education for the past fifteen years.

In towns where land is dear, schools have had to be built in several stories. These are limited by the child's power of climbing

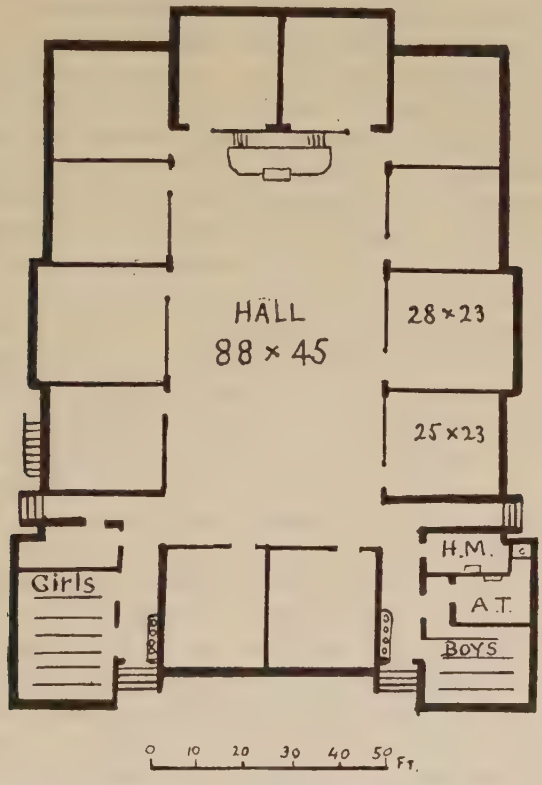


FIG. 139.—CENTRAL HALL SCHOOL AT GREAT HORTON, BRADFORD.

stairs, and the necessity of getting to the playground. Some roofs, especially in America, are used for play spaces. Wherever possible, solid roofs should be obtained in many storied schools and utilized for recreation, drill, and open-air purposes. Extensive and well-drained basements are desirable, not more than one-third of their height being below ground. The higher the basement out of the ground, the better for the lighting arrangements of the class-rooms above. This basement height could generally be saved by reducing class-room height, which is often excessive. In the basement of a large school should be boilers, coals, kitchen, dining-room, laundry

for drying towels, and shower-baths. These last provisions, although not a requirement, are almost a necessity for every school of over 250 pupils.

Much-sloped sites are likely to be costly in retaining walls, and the levelling required; for the playgrounds should be approximately level for games and to prevent accidents. Finally, in recent years, where site space has allowed it, approximation has been made to the open-air types of school, the class-rooms opening on to free verandahs instead of closed corridors. These schools, as a rule, are single story; bungalows covering considerable areas, and the hall here may be better detached from the class-rooms. A few old schools have been arranged with open-air class-rooms, where the whole of one side of the class-room can be opened up to a balcony.

Portable Buildings.—Various kinds of wooden or corrugated iron buildings are used for temporary purposes. The corrugated iron are not satisfactory; although wood-lined, they do not retain heat well, so that in winter they may be freezingly cold, whilst in summer they are often unhealthily warm.

The wooden standardized buildings in portable sections extensively used for the Russian hospitals in the Japanese War were later used for open-air schools and such purposes. They are sometimes called Döcker sheds, from the firm of patentees. The walls are double and are lined with a patent mixture of comparatively non-conducting material, which forms a smooth washable surface. In the examples used in Germany, and London open-air schools, one side of the class-room could be freely opened.

Reduction in the cost of school buildings is a matter for the architect, but there are considerable advantages in single-story buildings. Where the ground can be obtained, and with the exposure to open air now being generally asked for, there can be little justification for the erection of great masses of monumental building. The simplest buildings and material to comply with the necessities of protection from climatic extremes is all that can be asked for; beyond this, from the sanitary view-point, is waste. The writer's first impression of London schools was the poverty-stricken, mean appearance of even a well-furnished school-room given by the bare bricks of the wall, painted or washed over without cement. The psychological effect of such a room is very harmful according to modern ideas, producing the sense of inferiority. In addition, dust, although perhaps not of much pathogenic importance, yet finds temporary resting-places on the irregularities of such walls, and the rooms are never really clean.

Dr. Reid, of Staffordshire, first broke away from the stuffiness of the central-hall type about 1906 by ventilating class-rooms from both sides and making one side open on a verandah, as illustrated in the plans shown by figure. The class-room sizes there marked

are now out of date for the numbers, although the rooms themselves are the proper size for classes of 35 to 40 pupils. A somewhat similar type suggested by Crowley, and carried out by Kirby in Bradford, is remarkable for the extent of window opening and corresponding amount of heating area in the rooms. The securing of light and air in the class-room has perhaps been fullest worked out by Widdows in some of the new Derbyshire schools. These innovators may be said to have initiated a reform in school devising, which has been fully confirmed by the ideals of the open-air school, treated in an earlier chapter. The arrangement of the class-rooms and the connecting corridors and verandahs depends largely on the site. A few schools have been built with class-rooms, and other rooms opening to verandahs, which form the sides of a large square or oblong playground. Examples may be seen at Glasgow, Cambridge, and Letchworth. The curriculum of the open-air school,

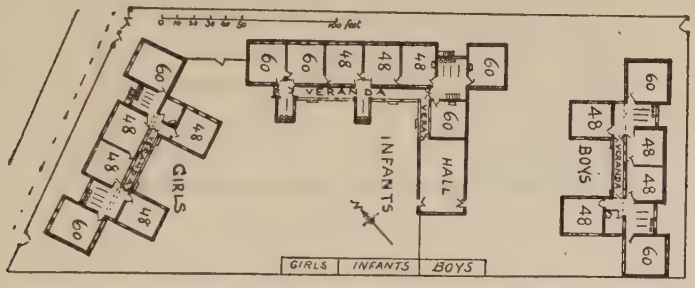


FIG. 140.—REID'S STAFFORDSHIRE SCHOOLS WITH THROUGH VENTILATION.

the constant movement, feeding, and siesta are health-giving factors, usually wanting even in the best class-room with continuous desk work on a restricted space.

Stairs and Corridors.—Staircases are the most used parts of the buildings. Steps in all schools must be standardized to the regulations. A step must not be less than 4 ft. long and 13 in. wide. Its height has to be 5½ to 6 in. The stair slope thus is about 30°. Sufficient width is important to keep an even tread, for the step edge easily wears, and some materials become dangerously slippery, causing many school accidents. In America all varieties of height and tread exist as each State attempts its own standard, and some are excessive, especially in height, for children. The suggestion from America that the nosing of all exit stairs should be painted white, or be such as to shew the edge of each step by contrast when viewed in descending, is worthy of universal acceptance. Outside stairs particularly require wide steps, or in winter snow and ice may make them almost inaccessible, and even without this the mud from children's shoes may occasionally make a stair

dangerous. In many infant schools, instead of steps to the outer door, slopes are used.

The height of the step affects the heart. Too high steps would make considerable difference in an ascent to the top story, especially in growing boys whose hearts are often easily dilatable. For the same reason stairs without handrails are to be avoided. A long flight is risky in case of accident or crowding, and the regulations prohibit more than fourteen steps without a break.

Corridors should be as wide as can be afforded. The tendency is to make them too narrow. All doors should open outwards. Glass partitions or panels in doors are inadvisable, and transomes over the door draughty and noise transmitting. Wherever possible, eliminate ledges and beadings, which are costly and harbour dust.

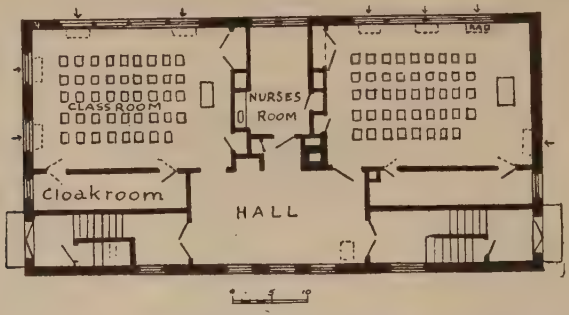


FIG. 141.—AMERICAN SCHOOL TO SHEW CLOAK-ROOMS.

A nurse's room should now be a requirement in all schools. The Boston specification is given shortly on page 644.

Cloak-rooms.—In the old schools hats and outer garments were hung on pegs round the room, or laid on window-sills. In many German schools the corridors are used for this purpose, and in newer schools there, recesses with hooks provided. The same arrangement also is found in America. In the typical American school, however, the cloak-room is arranged as a kind of antechamber to the class-room, either a passage-way to the class, or practically a piece cut off the length of the room. Probably this is the best arrangement for the enormous American schools, as each child has its own peg close at hand. Some of the older schools in Munich had similar arrangements. The walls should in all cases be finished smoothly. The English practice is to have a separate cloak-room for each department near the entrance. Where the departments are mixed, there are two cloak-rooms respectively. Entrance corridors used for this purpose are forbidden in the Regulations.

The Board of Education Regulations (1914) prescribe one row of pegs for secondary schools, with a minimum horizontal distance of 10 in. for boys and 15 in. for girls, and gangways of 5 ft. between

the stands. For elementary schools two rows of pegs are allowed, the horizontal distances of adjoining pegs being 6 in. for boys and 9 in. for girls. The gangways here are to be 4 ft. wide.

Very often the cloak-room accommodation is insufficient, and when it is wet weather, and the pegs perhaps 20 per cent. fewer than pupils, wet clothes are heaped on each other to become quite sodden. Each child should be responsible for its own peg; indeed, its name should be labelled there, and this should be separated by a division from the others. In infant schools the top row is sometimes almost inaccessible. For very small children it is convenient to have clothes-horses on wheels which can be wheeled into the school-room for the smallest ones to be clothed there by the teachers.

Wood fittings should be avoided, and concrete and metal tubing with stiff wire divisions is the hygienic practice. Heating and ventilation on an ample scale greater than the class-rooms is desirable. Dr. Elwyn Nash suggests that all cloak-rooms should ventilate directly to the outside air, and that the glass of the windows should be replaced by louvred glass. The lighting of most cloak-rooms is insufficient. They should be as well lighted as the class-rooms.

Water Provision.—Lavatory basins are often at one end of the cloak-room, but need to be separated from it. The Regulations require two basins for every fifty children in elementary schools. In secondary schools there is twice this provision for boys, and two and a half times for girls. The elementary schools probably require about 5 per cent. basins for the children, a little more than the 4 per cent. minimum laid down.

A water supply and provision for disposal of waste water is necessary. Both are frequently absent, though the basins may have been provided (p. 723). In residential schools it is an advantage to have sprays for washing, especially in residential, blind, industrial, or any class of schools where conjunctivitis may reasonably be expected to be introduced.

Uncleanliness of body is most marked among the leavers (Coventry, 1920), but to some extent this is not unexplained. They are the most active in group games, tumbling about in the playgrounds. In reports one reads the supply of soap and towels is inadequate or wanting (Coventry 1920, Cambridgeshire 1919, Durham 1921, Cardigan 1919). An American woman, writing in one of the London papers (*Star*, June 30, 1922), was horrified at the idea of children using soap and towel in common—" the common towel and common soap tablet prevented me sending my children to any school of any sort in London had I not thought out a plan for providing them with soap and towels for themselves." Meanwhile, in October 1911, the question of soap and towel provision was discussed at the School Hygiene Society in Berlin, and it was decided

that this could not be done (*Zeit.*, 1912. 468); and yet soap and paper towels are commonly provided for each child in the United States of America and Canada, and in some States required by the Regulations. Common roller towels are specifically prohibited, for instance, in Indiana and Kansas.

There are many suggestions that a mirror, large or small, should be provided, and it is certainly not a luxury for a self-respecting child to see what it looks like before going into class. These are educational accessories which develop the all-important esprit de corps, that herd instinct which is so valuable in civilized communities, and at present exists as a striving against inferiority in snobbishness, or is fostered by our obviously insufficient social arrangements as the "class war."

Drinking Water.—The provision of abundant drinking water is a necessity for children. No school not satisfactorily provided with drinking water should be recognized for a single day, yet one finds Medical Officers calling attention to this need. Cardiganshire has schools without, and the Medical Report (1920) states that about a quarter of the schools in Leeds were without drinking provision. A separate drinking supply is needed for every 100 boys and 135 girls and infants, according to the London standard. In summer a queue of children is sometimes seen waiting their turn. What its basis is does not seem evident, but the infants should certainly be well supplied. This provision applies to England. Drinking must be largely a matter of temperature and moisture, and American supplies have to be on a more liberal scale. Clay recommends that a drinking-fountain, best direct from the service main, should always be supplied in the playground (Clay, *Modern School Buildings*, 317). Abroad, both on the Continent and in America, some of these drinking-fountains in school playgrounds or school corridors are things of beauty as well as health.

The common drinking-cup, such as is attached to many municipal water sources in English towns, is an abomination; although the writer does not remember any case of actual disease in a school child traceable to this cause, he has seen cases of adult syphilis probably thus caused, so that it is a possibility. Diffusion of diphtheria by this means seems theoretically very probable. The "Sanitary School-house Law" of Indiana, 1913, one of the most scientific school codes existing, states, "whenever it is practicable, flowing sanitary drinking-fountains which do not require drinking-cups shall be provided."

The bubble drinking-fountain, originated in 1896 in Padua, "La fontanina Oreffice," called after the engineer G. Oreffice, who devised it for anti-tubercular purposes. It extended to America—"The Crystal Spring"—and has become widely known there. The writer inspected in Dusseldorf schools about a dozen years ago some large

ornamental stonework arrangements, a metre across, with seven of eight vertical jets on the margin, and newer Viennese schools have beautiful drinking-fountains in every corridor. In some arrangements, especially for use inside buildings, the child grips a metal circle with both hands and presses it down to cause the jet to spring up.

The phobia of the common drinking-cup in America is so great that some of the large insurance companies supply parchment paper cups as advertisements. In Aberdeen (1915) "bubble drinking-fountains have been introduced in all the schools, and the use of drinking-cups forbidden." There is little doubt that the bubble drinking-fountain, where the child cannot bring its lips in contact with the source, and where by a ring or some such means the bumping of its head by others will be prevented is the best method of providing drinking water. Ohio requires the jet to be not less than 2 in. to provide efficient cleansing. It should be the obligatory method in all schools with running water supplies.

In the case of residential schools, the water supply becomes a matter of even greater importance. Over a hundred cases of mild typhoid occurred in an industrial school at Brentwood in 1901, where, although the water supply was good, water for scrubbing floors was got by dipping a bucket in a stream. This water was not used for culinary purposes, but was drunk by the boys when working in a cellar to save going upstairs, with the result that many were infected by a typhoid case further up the stream.

The Rules of the Medical Officers of Schools Association state—

1. Whenever possible the drinking water should be obtained from pipes on a constant service ; or, if the supply must be intermittent, from cisterns distinct from those supplying water-closets, urinals, and slop sinks.

2. All cisterns (which should be suitably placed, properly covered, and easily accessible) must be frequently inspected and periodically cleansed.

3. When well-water is used, the surroundings, and the possibility of contamination by cesspools, drains, surface washings, and deposits of foul matter in its vicinity, ought to be investigated. It is also advisable to have the water periodically analysed (chemically and bacteriologically), and this not always at the same season of the year.

4. If filters be used, they should be fitted with candles of the sterilizing type, and care should be taken that they are in good working order, with neither cracks nor flaws.

Sanitary Offices and Toilets.—The offices should be separated from the main building, except the provision for the female staff, which should be on the same floor as their work, if possible.

For elementary schools the separate arrangement in a detached building is probably still best and indeed is required in England. In America and on the Continent the provision is frequently in the basement. The outdoor provision is probably a relic of the days of the insanitary voluntary school and the trough closets. In towns

with wash-down closets, if the teachers were alive to the proper supervision of the toilets, and clean habits inculcated in the children, there is no reason why these arrangements should not be under the same roof as in the homes.

The teachers must be responsible in all cases for the condition of the offices, which need frequent inspection. The educational influence in promoting a sense of decency and cleanliness is very great, and of importance as an element in public health. This becomes a supremely important matter in regions where hook-worm is prevalent. All tendency to larking or horseplay about the offices must be severely repressed. Good lighting is required in every part. There is no reason for the little prison-like windows so often found. The windows louvred and large will afford abundant ventilation. In the English climate there can be free exposure to the open air, and latrines are often not roofed over. It may be necessary to make special arrangements to prevent freezing. Cement floors, properly sloped, and preferably coated over with asphaltum are non-absorbent and impervious. The walls are preferably glazed with tiles, or rough cast to prevent inscriptions. Collapsible metal entrance doors are especially cautioned against by those who have had experience of them. For privacy, closet doors of plain wood can leave a clear 6 or 7 in. open at the bottom.

Ordinary pedestal wash-down closets, as in the homes, are wanted, to be flushed by the user pulling a chain handle. Automatic tip-up cisterns for periodical flushing should also be used. They can be adjusted to frequent or seldom flushes by regulating the water-supply tap. Trough closets should be abolished whenever occasion occurs.

Where there is no water carriage, a pail system or earth closets may have to be used, pits and cesspools being avoided. Further detail as to these will be found in the Appendix to the Building Regulations for elementary schools.

Whatever the arrangements may be no report on a school's work or efficiency is complete unless it includes a definite statement on the cleanliness and order of the toilet arrangements. American rules generally reckon 1 seat to 15 girls and 1 to 25 boys. The English regulations prescribe the number of closets to be provided for girls and boys respectively—

TABLE 98.

Number of Children	30.	50.	70.	100.	150.	200.	300.	400.
Number of closets respectively—								
Boys	1	2	2	3	3	4	5	6
Girls	3	4	5	6	8	10	14	18

In addition, boys' urinals in the proportion of 10 ft. per 100. For secondary schools 1 closet-seat for every 25 boys and 1 urinal for each 15. For girls 1 seat for every 15 up to 100, then 1 for each 20 in addition.

Special provision is required in infant schools. The seats are often too high. Supervision, too, is wanted. The writer recalls encountering a very small boy who had been allowed out and then found he could not manage braces and buttons, and was howling away his afternoon in a kind of Freudian terror not daring to return to school *en déshabillé*. The nursery school will probably obviate this, when it becomes the rule.

General Sanitation.—The general hygienic arrangements of all schools require frequent overhauling, and in the case of residential schools this is even more necessary. The points to be attended to in such a survey are set out in the Code of Rules of the Medical Officers of Schools' Association (Eighth Edition, 1923).

All the sanitary arrangements of the school should be inspected by a competent person half-yearly, and any defect remedied as soon as possible.

Amongst other essentials, the following points require special attention, viz.—

1. That all foul water drains should preferably be of iron piping; they must be efficiently ventilated, and cut off from the sewer by a disconnecting chamber.

2. That all soil or vent pipes be fixed outside the buildings; that they be efficiently ventilated and properly disconnected from the sewer.

That the joints of all soil and drain pipes and their branches are air and watertight.

3. That the closets be of a wash-down type which prevents the accumulation of sediment or of sewer gas. It is desirable that closets should be placed in detached or semi-detached buildings efficiently ventilated, and not in the basement of the school.

4. That no drains pass under the school buildings, unless this be unavoidable. In such a case there should be iron pipes, laid so as to be accessible for inspection or repair.

In localities where there is no efficient drainage, earth closets may be adopted and should be placed in detached buildings.

In exceptional cases, where a cesspool must exist, this should be placed no nearer to a dwelling-house than fifty yards. It must be watertight, efficiently ventilated, and so constructed as to permit of its being emptied without nuisance.

5. That all overflow, rainwater, and waste pipes be properly trapped and disconnected.

6. That no fixed dustbins be permitted, but that each day's dust and refuse be removed to a distance, and efficiently dealt with.

7. That all drain gullies be kept clear and frequently flushed at regular intervals, including the holidays; otherwise the water in the traps may dry up, and drain air thus escape.

8. That an accurate plan of the drainage and of the water, gas and electric-light mains should be provided, and that a copy of this should always be accessible, and kept up to date.

Space of Class-rooms.—The unit for education is a child. It is a platitude to suggest that everything educational must stand or fall according to the way it fits in with the welfare of the individual child ; too often this is almost the last consideration with Education Authorities intent on saving rates.

Children can be arranged in classes, but the class is never homogeneous ; classes again form departments, and departments schools, but these are administrative concerns built up chiefly from financial considerations.

A class is formed round a teacher, but the personal relation of teacher and taught is invaluable, and the more so the younger the child. Formerly it seemed to be supposed that the smaller the

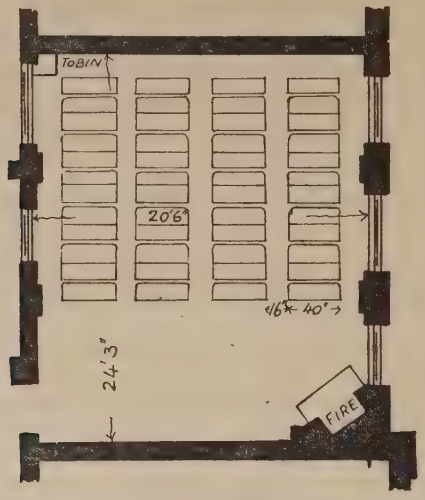


Fig. 142.—LONDON "FORTY-EIGHT" ROOM.

child, the more went to fill a class. The writer vividly recalls a melancholy and flabby elderly woman, much wrapped up, in a room that smelt like a zoo, with all the windows and doors shut to prevent a draught which gave her cold feet. She was the head teacher of an infants' department and supposed to be teaching a class, on a gallery holding 128 tightly packed "infants."

No one should pretend to teach a class over 35 in number, whether infants or older children. In a secondary school the number allowed is 15 to 30. Formerly much larger classes were not infrequent. Without a statement of numbers in the rooms, the many plans of schools, with dimensions, published in various books, are of scanty use to determine the relative sanitary areas and value of the rooms.

Before the War Prussian Regulations gave the maximum as 80 for a one-class school ; whilst in schools with more than one class 70 was the maximum permitted in a class. The large German

text-book of Selter (1914) lays down that there should be 40 to a class in rooms 9 × 6 × 3·8 metres, giving 1·06 q.m. floor-space, or at least 4 cubic metres per head. In France 1·25–1·5 q.m. and 5 cubic metres are required; in Belgium a little more than France. In Prussian Regulations (1914) the classes of 80 were allowed a room 9·7 × 6·5 × 3·2 metres, or 0·78 q.m., and 2·4 cubic metres per head, a square metre being 10·75 sq. ft.

The numerical size of class in England was steadily diminishing until the War gave anti-social forces their opportunity, at the expense of the child's future, to reduce rates instead of classes. In London primary schools, during the ten years before the War, the average class dropped from 46 to 42 in council schools, and

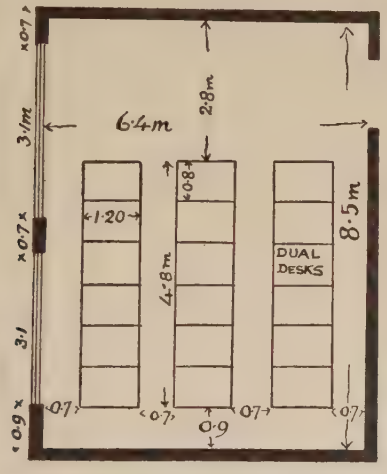


FIG. 143.—ERISMANN'S PATTERN SCHOOL-ROOM AT MOSCOW EXHIBITION.

from 39 to 37 in non-provided. Our English fault is the miserable space allowed in the class-room. The standard 48 London class-room is not suitable for more than 30 to 33 children according to reasonable standards. The Building Regulations (1914), whilst disclaiming any hard and fast rules, lay down certain requirements which control the area of class-rooms. In elementary schools a hall, where provided, should be 3½ sq. ft. per head, secondary schools must have an assembly hall at least 6 sq. ft. per head, and, if the school be less than 150, preferably 8 sq. ft. The elementary school allowance of 3½ sq. ft. for hall appears too restricted; 4½–5 ft. would be more reasonable. If the whole school is to be assembled at times, the larger amount is almost a necessity for avoidance of infections.

The elementary class-rooms suggested are two for every 100 pupils. In no case should every class-room be planned for 60 at a time.

The area is defined as not less than 10 sq. ft. per head for children in the standards, and has been raised to 12 sq. ft. for those over 11 years of age and 9 sq. ft. for younger children in infant departments. In the secondary schools there are to be four class-rooms to every 100 children ; they are designed for not more than 30 or less than 15 pupils. This provides about 6 to 18 sq. ft. per head, but in no case is it to be less than 16 sq. ft.

In 1913 in Prussia, the average space per head was 1 sq. metre (10·76 sq. ft.) and cube 4 metres. In South Germany the writer noted average class-rooms : 54's room at Stuttgart was 7 × 8·5 m. = 1·1 q.m. per head ; 48's room Torstr. Halle was 6 × 7·9 m.

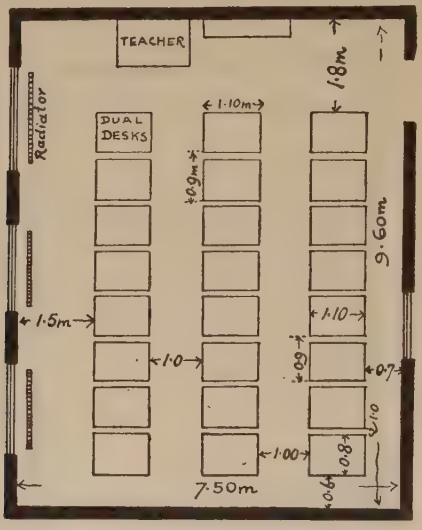


FIG. 144.—FRENCH CLASS-ROOM, ACCORDING TO THE REGULATIONS.

= 1·0 q.m., and the model class-room shown as normal at the Dresden Hygiene Exhibition was taken as for 50 children and 9 × 6 m. = 1·08 q.m., or 11 sq. ft. per head.

In other lands the allowance is much greater. Stockholm (Mariavolkschul) classes for 35 and 42 are 13·5 sq. ft. and 13·4 sq. ft. respectively. Drontheim 37 classes allow 14·5 sq. ft. Russian schools represented by a model one-sixth size at Moscow Exhibition had 36 scholars in dual desks in rooms 8·5 × 6·4 m. giving 1·5 q.m. per head or 16·5 sq. ft. each, many years ago. It has an area of 545 sq. ft. against the London 48 room area of 496 sq. ft. At the Copenhagen Exhibition the same year (1888), a model class-room for 30 children was 22 × 20 × 11 ft., giving 14·7 sq. ft. per head. Le règlement français prescribes 1·25 q.m. per child, but a room worked out according to regulations is for 50 children 7·5 × 9·6 m. = 72 q.m., or 1·44 q.m. per head, which gives 14·87 sq. ft. In

Belgian schools this according to regulations is 1·5 q.m., or 16·1 sq. ft. Some other French plans for 48 in dual desks give 1·28 m., in single desks 1·47 m., and 50 places single = 1·42, or approximately 15 sq. ft. per head. Turning to America, Briggs, the standard writer on School Architecture, says, page 271 : "My rule is to allow at least 20 sq. ft. of floor space per pupil, never less—always get as much more as you can." His plans work out, 46 rooms = 21·1 sq. ft. per head and 50 rooms ("I am sorry to make") 28 × 38 ft. = 21·3 sq. ft. per head. In Wisconsin (1881), "each school-room is to accommodate 35 pupils in single or 42 in double desks." Each of the former would have 19·7 sq. ft., and of the latter 16·5 sq. ft. In the Bridgeport High School (1891) each pupil has 20·5 sq. ft., and 266 cubic space, and in the High School 17 sq. ft. and 441 cubic. The standard room adopted for Boston for 50 children gives 15·6 sq. ft. The district of Columbia School-house Commission, 1908, recommended a class for 42 pupils as having 250 cubic and 19·2 sq. ft. per pupil.

The desirable space basis and class numbers for elementary schools may be expressed roundly as gathered from regulations and published books or papers as—

Table 99.

Country.	Class-room Space per Pupil.	Number in Class.
	sq. ft.	
England	10 (or 12 for over 11's)	50
Prussia	11	70
Bavaria	11·8	54
Saxony	10·7	48
France	15	50
Belgium	16	50
Finland	19	40
Denmark (Copenhagen)	16	50
Russia	15	30
Italy (Palermo)	15	48
Norway	16·5	36
Sweden	13·5	42
America	20	48
British Columbia	20	48

The Regulations require the height to be not less than 12 ft. if the room has a flat ceiling. If it is ceiled at the collar beam the height should be 10 ft. to the wall-plate and 13 ft. to the ceiling. The ceiling should extend over at least half the area of the room. In no case may a class-room be left open to the ridge. The height of rooms need not now be discussed, as they are not likely to be below 12 ft., the English minimum, and all height above this is nearly lost space, only beneficial from allowing more light through the

higher windows. The use of mezzanine rooms for cloak and teachers' rooms gives insufficient height to these, and, on the other hand, wastes height in the class-rooms. London school-rooms are too high by a couple of feet, increasing cost. At the present, the standard size of an English urban elementary school, in London, for instance, is 1024 pupils made up of three departments : Boys 320, girls 320, and infants 384. Each department being in eight classes of 40, and, in the case of infants, 48. It would seem desirable that the crowded rooms should be thinned out in the numbers of pupils till a space approximating to 15 sq. ft. per head is attained. This could be done in many classes by reducing the numbers to 35, and would call for little alteration to buildings, but would mean building many more new schools. The time to effect the change will be within the next five years (1925–30), when the diminished (War) crop temporarily leaves places unfilled. It is time to give up squalid ideals in relation to the elementary class-room.

In a survey of elementary education in England made in 1913 by Kandel for the United States Bureau of Education (Whole Number 568, No. 57. 19) : " The rooms, even in the newer schools, are so small and compact that they permit of nothing but seat work ; the provision of space in front of the class is generally very scanty."

In 1892, Mangenot, a Medical Inspector of Paris schools, reports in *Revue d'Hygiene* his surprise at the size of our schools ; " in spite of great advances of recent years the rooms are with 1 m.^{2} floor area and air space 5 m.^{3} per head." Actually they are 10 per cent. less than he notes.

And even these requirements tend to lessen, for it was reported in 1917, under one of the greatest authorities in the country, that " new schools are much smaller than many of the older ones ; they are built to satisfy barely the requirements of the Board of Education and little or no storage accommodation is provided."

It is a mystery why elementary schools should be only allowed 9 and 10 sq. ft. per head and secondary schools required to have 16 to 18 sq. ft.

The National Association of Head Teachers in 1919 " is of opinion that the accommodation and arrangement of elementary school buildings is inadequate and unsatisfactory . . . amount of floor space per child to be increased to that allowed in secondary schools. . . ."

The small size of the English rooms cuts off many activities seen in American schools ; for instance, there is less use made of blackboards ; spontaneous activities are almost ruled out, and free-arm drawing, which should be one of the chief means of education in earlier years, is non-existent, except in the make-believe substitute on desk cardboards. The great defect, however, is the

personal contact of the children, the horrible *bouquet d'enfant* on a winter afternoon, and the absence of possibility of single seats and desks which make for cleanliness physically, but also for self-respect and development of individuality instead of fostering a latent sense of inferiority as is so frequent with the primary school child at present.

Dr. Josephine Young, however, writes: "In the winter of 1918–19, during the epidemic of influenza, an investigation was made of some sectarian schools in Chicago located in a district reporting an extraordinary number of deaths. It was found that the school-rooms measured 16 by 24 ft., there was no artificial heat, the windows were kept closed, and there was dry sweeping. The children were packed as close as possible on benches; 140 in one room, 104 in another, and several other rooms ranging from 66 to

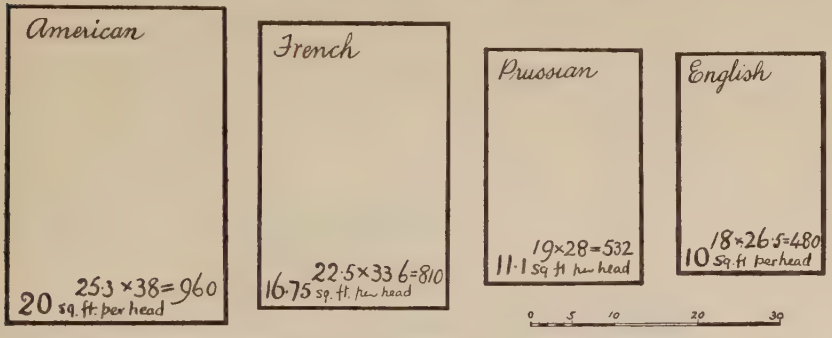


FIG. 145.—COMPARATIVE CLASS-ROOM AREAS REQUIRED BY REGULATIONS.

90." Evidently there are lower depths than are found in our own non-provided.

These separate topics are dealt with in other chapters.

From considerations of lighting, height economy and angle of teacher's vision, to arrange a class-room, neglecting irregular shapes, the room should be an oblong of width W, approximating to two-thirds the length L. But the whole area A = W L, and also the area a per head multiplied by n the number of pupils $A = a\,n$, so that $W\,L = a\,n$ and multiplying out $W^2 = \frac{2}{3}a\,n$ or $W = \sqrt{\frac{2}{3}a\,n}$. If 15 sq. ft. per head is allowed, then $W = \sqrt{10\,n}$.

Calculated on this basis for a class of 48, the sizes of the standard class-rooms according to the Regulations of the four chief countries are given in the figure.

For English schools the width will also be determined by the safe rule: "No desk in a school-room should be further from the window than twice the height of the top of the glass above the desk surface." If the desk be taken as the adult size of 30 in., and the top of the window as 12 ft., then the centre of the farthest desk

from the window should not be more than 19 ft., and with an 18 in. gangway this would give the maximum width of the room as 21·5 ft. It may be taken that for the latitude of England to avoid needless height the limit of width of a class-room is 22 ft., and the nearer it is kept to 20 ft. the better. According to the late Lord Sheffield, the London School Board had to fight the Board of Education's demands for desks 24 ft. from the windows.

The area covered by desk and seat should be stated in class-room descriptions, by extreme dimensions in width and depth. Although the Regulations allow a width of 18 in., this is insufficient. Not less than 2 ft. are necessary for the average of children over ten years of age, whilst 21 in. may do for those below ten. The

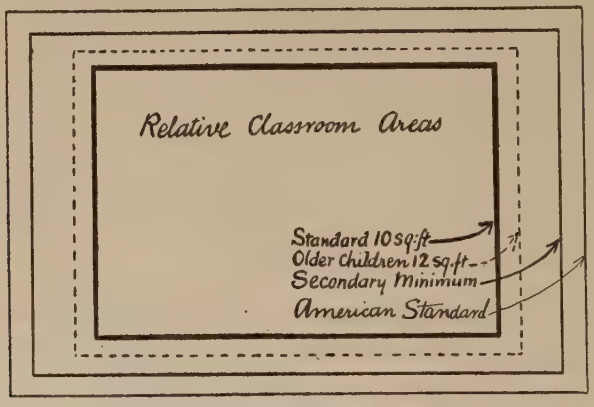


FIG. 146.—ENGLISH CLASS-ROOM AREAS COMPARED WITH AMERICAN STANDARDS.

depth will be approximately 3 ft. for older children and 2½ ft. for younger.

The Board of Education rightly demand a space for the teacher of 7½ ft. depth for the whole width of the room in front of the desks. An 18 in. corridor should intervene between window wall and the nearest file of desks, and a similar gangway between each file and next the farthest wall. Usually a gangway is also asked for behind the back row. It is not a necessity from the sanitary point of view, although convenient. On the above allowances for children a 35 room with single-seat desks would be 19 × 30 ft., giving 16·3 sq. ft. per pupil.

For smaller children a room of this size would take another row of desks giving 40 places at 14·2 sq. ft. each. On this basis a 48 room would be 22·5 × 33 ft. or 742 sq. ft., giving 15·5 sq. ft. per head.

This is considerably less than the standard American room figured above, but half as great again as the London class-room.

Considering the clothes, cleanliness, motor activities, and lively metabolism of the younger children, and the experience of other countries, it may be concluded that class-room space should not fall below 15 sq. ft. per head. For a class of 35, which other reasons make acceptable as the limit for children over 10 years old, such a room would be 19 ft. across and 28 ft. long, and it need not be more than 12 ft. high.

Roughly speaking, this means a 50 per cent. increase of accommodation in English elementary schools, writing down the accommodation of existing schools, and providing new ones to afford the room wanted. In spite of all these considerations the 10 sq. ft. basis is in practice a strictly adhered to maximum. The difficulty in obtaining the conditions necessary for health lies in the ignorance of members of Education Committees who accept the Regulations of the Board of Education as sufficient. This was well illustrated some years ago by a long printed memorandum from the architect of a big school justifying his work to the authority who had complained that in the building there was an excess of space of 0·56 sq. ft. for each girl, 0·31 sq. ft. for each boy, and 0·15 sq. ft. for each infant. The main reason appeared in the summary: "Of course to build the walls of an unnecessary thickness to the full height of the school, so that only the statutory floor space would be given, would be wasting hundreds of pounds."

As late as 1914, after a correspondence in regard to a central school, the Board of Education realized that in regard to practical subjects "special rooms may be *larger* than ordinary rooms need be. In future they will be prepared to approve plans for central schools which show a reasonable proportion of rooms of dimensions which allow accommodation on a higher basis than that of 10 sq. ft. per child under instruction."

From other considerations of ventilation, lighting, contagions, and infections, it will be shewn later that until this 10 sq. ft. basis be increased by 50 per cent. we must say of the English elementary schools that, except in the matter of audibility of the teacher's voice, there is no health in them.

The writer is ashamed to think that after he had been twenty years in the London Educational Service the Education Authority is still proposing to build class-rooms of 20 by 20 ft. No class-room should have less than 600 sq. ft. floor area. The first real advance in this regard took place in 1924 in Circular 1325 (February 22, 1924), when the Board of Education intimated that future class-rooms for children over eleven must not be planned for more than 40 pupils, and again in July 1924, Circular 1334 stated that the time has now come to establish 12 sq. ft. as the minimum for older children, that is on an average 11 years or more. They also refuse to accept a class-room of less than 400 sq. ft. Still English

schools must be regarded in the matter of space as among the worst in the world.

A résumé of official requirements may be here given as the Board of Education issue Building Regulations for Public Elementary Schools (Cd. 7516. 1914) which they believe to represent current practice.

The Board have recently stated in the Code (May 1926) that at the present moment it is desirable that Authorities "should consider themselves free to suggest a new departure from the Board's current practice on any point where such a departure seems to them desirable."

Taken as a whole, the Regulations are not a code of precise and definite rules with which compliance is required. The chief points may be set out—

10. Space for a playground the minimum area . . . quarter of an acre for every 200 children.

20. As a rule, there should not be less than two class-rooms for every hundred scholars.

48. The height (of class-rooms) should not be less than 12 ft. if the room has a flat ceiling.

(Regulations for lighting are given, page 814, and ventilation, page 792; furniture, page 200.)

66. Class-rooms for practical work should provide not less than 15 sq. ft. of floor area for each scholar.

70. A Handicraft room for twenty scholars should have a floor space of at least 600 sq. ft.

76. For Cookery or Laundrywork at least 25 sq. ft. of clear floor space is required for each scholar under instruction at one time.

87. In rooms for younger children in all cases at least 9 sq. ft. floor area per head. When children are retained over 7 years of age "the Board may require some of the rooms to be reckoned on the 10 sq. ft. basis."

101. Rooms may be provided for the purposes of the School Medical Service. A convenient arrangement consists of (*a*) one room for the actual work of inspection, which should have a space of 20 ft. in one direction for eye testing; (*b*) a small waiting-room, and a lavatory and water closet conveniently placed.

Dust in buildings may be an irritant, but as a source of disease in schools it has been enormously overrated. The New York Ventilation Commission had difficulty in detecting any serious contamination. The numbers of organisms depend on the system of ventilation, the condition of the streets, and the weather.

Dust-binding solutions used to water the playgrounds, such as the "Duralit" used in some German towns, considerably reduce dust in school.

Dust-binding oils used on wooden floors have a similar effect. The oil only requires applying at long intervals, and as it requires two or three days to settle in this is usually done in the holidays. A daily sweeping with damp sawdust is useful to

remove crude materials. No washing is required. As the floor becomes dark from the skin of retained materials on it, a good washing over with soda should be suggested before the holiday re-oiling.

This is preferable in towns to any sweeping methods. The most satisfactory flooring for class-rooms would be a covering of linoleum. For this vacuum cleaning gives a result beyond any other method of cleansing. Tests some years ago in Hamburg showed the vacuum systems preferable for all classes of schools. It is, however, disliked by school-keepers as it takes more time, and the larger pieces of paper have to be previously collected.

Dust is also much kept down by plenum ventilation, especially if there is no heat carriage by the air.

CHAPTER XL

VENTILATION

Historical.—Almost as important as the care of vision is attention to school ventilation. The use of space and good ventilation as measures of economy in public health has been long overlooked, and almost unknown to most of those who administer schools.

Ventilation and heating are treated as if they were the same topic. Physiologically they are antagonistic, and architecturally or from the engineering point of view they require separate consideration and independent mechanisms.

Ventilation denotes, and its greatest importance lies in, removal by means of air of large quantities of heat produced by metabolism. As a secondary consideration, ventilation includes supply of fresh air carrying oxygen, and the removing of exhaled aqueous vapour and carbon dioxide. But for the necessity of heat removal, ventilation would be quite a trivial affair.

Children would not live for five minutes without air, but the function of respiration (as distinct from the process of ventilation) would proceed normally in any atmosphere ever likely to be met in a school-room.

The inbreathed air contains by volume about 20·94 per cent. of oxygen and 0·04 to 0·01 per cent. of carbon dioxide. Outbreathed air contains 16·03 per cent. oxygen and 4·4 per cent. carbon dioxide. In addition, its temperature is raised, and the aqueous vapour is nearly at saturation. These last two items are the result of the mucous surfaces acting like the skin in a ventilatory way.

Carbon Dioxide as Impurity Index.—Replacement of oxygen taken up from the air, and removal of exhaled carbon dioxide, was formerly looked on as the most important consideration in the atmosphere of rooms. Carbon dioxide was regarded as a poison which should not be allowed to accumulate. Deficiency of oxygen was thought to be the cause of anæmia and air hunger. This was due to misreading work of the great authority von Pettenkofer of Munich (*Leibig's Annalen*, 1862–63). He appears to have realized the main factors in respiration and ventilation, and suggested that neither the amounts of oxygen nor carbon dioxide produced through want of ventilation accounted for the symptoms, but

that for hygienic purposes the volume of carbon dioxide in air fouled by human occupation, compared with that in the outer air, was a safe indicator of its physiological utility.

This adoption of carbon dioxide as an indicator, diverted attention from other factors, which became overlooked.

There were suggestions that in exhaled breath, dangerous poisons existed in small amounts, and fouled the air. Brown-Sequard and D'Arsonval (*Compt. Rend. Soc. de Biol.*, 1887. iv. 814) had postulated a poison, anthropotoxin it was called by Du Bois Raymond, on the basis of animal experiments, which were not confirmed.

Known animal poisons in air are various decomposition products, chiefly ammonia or sulphur derivatives, gaseous, and otherwise, from carious teeth, nasal secretions, stomach and intestinal sources, or even from unclean clothes or unwashed skin.

These products are offensive in odour, and in action psychic rather than toxic.

Von Pettenkofer had referred to heating of air as one of the physiological effects of which the carbonic acid index would be an indicator. Hermans, in Hamburg (*Arch. f. Hyg.*, 1883. i. 1), observed that his own temperature rose in crowded places, and dissatisfied with chemical explanations, formulated a theory that ill effects of poor ventilation were due to heat accumulating in the body. Up to this time use of Pettenkofer's CO_2 index had been of considerable value. De Chaumont stated that the extraordinarily acute sense of smell was a good detector of the degree of impurity from human occupation. Owing to rapid fatigue of this sense, the observer should come straight from outside air to the atmosphere to be tested. He noted that damp air smelt more than dry, and classified the condition of inhabited rooms as related to the carbonic index.

VOLUMES CO_2 IN 10,000 (De Chaumont).

	Per cent.		Per cent.
Just noticeable odour at	6·0	Very close at	9·5
Not very close at ..	7·0	Extremely close at	11·0
Close at	8·0	Very close and unpleasant at	15·0
Not very foul at ..	8·5		

Subjectively, however, it is impossible to judge the chemical condition of the atmosphere. Pure, clean air outside on a still, warm summer day may be horribly stuffy, close, and objectionable, whilst the relatively dirty and chemically altered hot air in a theatre may seem pure and clean when felt directed by a fan or through an open door.

The CO_2 index which Pettenkofer suggested was, that with outside air having 0·04 per cent. by volume of CO_2, the atmosphere

of rooms should not be allowed to exceed 0·06 or 0·07 volume of CO_2.

The whole idea of ventilation to the end of the century was concentrated on air removal to keep carbon dioxide diluted down to 6 or 7 volumes in 10,000.

For instance, in cotton-spinning sheds which had to be hot and moist, to make the cotton spin well, the difficulties of the workers had caused legislation. In the Act of 1889 each person was secured 600 cub. ft. of space. In 1897 the amount of CO_2 was not to exceed 9 volumes when that outside was 5 volumes. Ultimately in 1909 the CO_2 was not to exceed 8 volumes over the outer air (*Lancet*, June 12, 1909. 1718).

Warmth as Deterioration.—So far as chemical constitution was concerned mechanically ventilated plenum schools were extraordinarily pure in their air, but they had not the physiological advantages expected.

From further experiences of ventilation in school, under the School Board for London, the conclusion was arrived at experimentally that even flow of warmed air causes a feeling of deadness and inertness; and later, that the chief part of the heat distribution to the rooms of the building should be by other means than air (*Reports of M.O. to London School Board,* 1902 and 1903).

This empirical result of mere observation agrees with what has now been determined on theoretical grounds.

About this time Haldane's work on physiology of respiration, and on working capacity in hot, moist mines, altered ideas as regards the proportions of the chemical constituents of air. He shewed that there was constantly 6 per cent. CO_2 in the alveoli of the lungs, and that it was not altered by atmospheric variation of the CO_2 breathed.

He stated the physical effects of CO_2 in any probable atmospheric contamination as nil. He attached much importance to temperature and humidity as shewn by the wet bulb thermometer, and determined that work in mines became impossible with a wet bulb thermometer reading 89° F.

The Oxford work of Harvey Sutton, now the School Hygienist in Australia, on heat stroke (*Journ. of Path.* xiii. 63), by experiments on himself, fully confirmed the value of wet bulb readings.

The various papers of Haldane and his pupils published in the *Journal of Physiology* in the first five years of the century, estimated all the important facts in the theory of ventilation (*B.M.J.*, August 13, 1904).

About the same time Flügge, in Breslau, with his assistants, Heymann, Paul, and Erklentz, developed the *Wärmestauung* or heat-retention theory, on a simple experimental basis, in four

papers published in 1905 (Flügge's paper is translated in *Public Health*, 1906. *Über Luftverunreinigung usw. Zeit. f. Hyg.*, xlix. 1905. 363).

Flügge used a glass chamber of about 100 cub. ft. The inside atmosphere could be varied in respect of temperature, humidity, movement, and carbon dioxide content. As long as the temperature was below 20° C. (69° F.) the patient could remain without trouble for hours, with percentage humidity varying from 47 to 72, and carbon dioxide rising to 10 or even 16 volumes per 1000. If the temperature was 30° C. (96° F.) the patient could not long endure it, the humidity running between 47 to 90, but the carbon dioxide never exceeding 13 volumes. On setting the air in motion the discomfort vanished. Increase of skin temperature and moisture shewed that the normal path for escape of heat was insufficient. With the head only inside the chamber, there were no symptoms in spite of breathing the foul, warm, moist air. When the body was in the chamber, and the head out breathing fresh air, the condition soon became intolerable; although again discomfort was at once relieved by setting the air inside the chamber in movement with a fan.

The work of Haldane and of Flügge was fundamental, and in 1906 it was used to afford full explanation of the results of ventilation in regard to fatigue, in a fresh enquiry in London schools carried out by Drs. Thomas, Hogarth, Brincker, and Stephenson (*Report of the Med. Off. Educ., L.C.C.*, 1907. 58).

Since then hundreds of workers have been in the field, but although elaborated in details, the solution of the problem has not been materially altered.

It has been reviewed, retested, and simplified by Leonard Hill, who has demonstrated in every way its hygienic importance (*The Science of Ventilation*, Stationery Office, Pt. i. 1919, Pt. ii. 1920).

Organic Impurities.—A side-issue which produced considerable literature, but may now be taken as not proven, was the work of Weichardt (*Arch. f. Hyg.*, 65. 252, and 75. 265), who supposed that he had detected a material in expired air which was also the chief cause of fatigue—kenotoxin. He prepared an anti-kenotoxin, a solution of which could be sprayed about a class-room to prevent fatigue. The effects were probably the result of suggestion.

Rosenau, in America (*J. Med. Research*, 1911. 35), thought on the basis of anaphylactic experiments that he had detected toxic material in expired air, but this has also been disproved. As Haldane puts it, "there is no instance of a volatile protein," and Lee, "the mysterious miasmic source of malaria lies only in the body of the mosquito."

For anyone intending to make enquiries in regard to ventilation, a useful paper, detailing methods, is found in the *Journal of the*

Royal Sanitary Institute, March 1908, on the relative hygienic values of gas and electric lighting by Dr. Samuel Rideal.

The series of problems in ventilation has been gone over anew, at great expense, and with care to avoid experimental error, by a team of able workers under Professor Winslow, the Chairman of the New York State Commission on Ventilation. They have published many separate papers on every aspect of the subject, and the whole is now reviewed in a large Report (*Ventilation*, 1923, New York. E. P. Dutton).

The Things that do not Matter in Ventilation.—Investigation shews that deficiency of oxygen is not the cause of vitiation of atmosphere. Haldane demonstrated that oxygen can be reduced to 12 or 13 per cent. of an atmosphere without noticeable effect. The CO_2 in the alveoli of the lungs remains at constant pressure. In the stimulating air of the Alps, where the barometer stands 4 or 5 in. below that of sea-level, the amount of oxygen is much less than in the air of the foulest gallery of a London theatre at midnight.

In the High Andes people live where the oxygen is only 12 to 14 per cent. that at the sea-level. So that any probable change in the oxygen content will not affect the air hygienically.

In regard to carbon dioxide, the air of breweries often contains excessive quantities of CO_2 without appreciable effect on the workers. It is only near lime-kilns, or in excavations, where its weight excludes oxygen that it becomes dangerous.

During the examinations carried out in London schools in 1906, large volumes of carbon dioxide were liberated in the ducts of a mechanically ventilated school giving 60 volumes per 10,000 without appreciably physiological effect (*Report L.C.C. Med. Officer Ed.*, 1906). Pettenkofer found no ill-effects with 100 volumes of CO_2 in 10,000, and Angus Smith went up to 300 volumes before he thought he detected effects.

Haldane's tests shewed that carbon dioxide had no effect on the alveolar proportions unless it was present in the air to about a hundred times the amount in outside air. In cold weather, with a slight increase of alveolar tension of CO_2, he noticed a sense of well-being. Any probable variation of carbon dioxide in the air may therefore be neglected.

The other inert gases, nitrogen and the rarer gases, may also be neglected for respiratory purposes as mere diluents whose proportions scarcely vary.

Odour of the atmosphere is chiefly due to gases, but also to particles or droplets of albuminous decomposition products from the body. There is no evidence that these are deleterious, although psychical effects at first may be strong. The sense of smell detects extraordinary dilutions of odorous material, but is rapidly exhausted.

Smells cease to be noticed in a very short time. Factory workers tolerate violent odours and even stinks.

Teachers' claims for illness caused by odours and smells in schools are never justified.

The New York Commission thought that the odour of respired air affected the appetite in some degree, an observation that had not been made before.

In small amounts ozone is a deodorant, which covers or destroys odours or powerful and clinging smells such as onions, garlic, Limburg cheese, decaying fish or meat, fertilizers, or the stale odour of tobacco smoke. Even in the weak proportions needed, it is likely to be harmful by irritating mucous membranes.

The respiratory membranes, according to Mill and Flack (*B.M.J.*, March 1, 1919), are more easily attacked by ozone than are various micro-organisms. A temperate article on all aspects of ozone for these purposes is "Ozone in Ventilation," by Milton W. Franklin, in the *Heating and Ventilating Magazine* (N.Y.) for October 1913.

Ozone being generally produced by silent electric discharge across a current of air, refreshing effects are probably due to the movement of the ozone-carrying current, and Hill (loc. cit.) suggests that the slightly irritating action on the mucous membranes may stimulate them to pour out lymph and destroy adventitious micro-organisms, thus aiding a natural immunity, yet, whilst there appears a definite place for ozone in industrial work, for regular school purposes it is unnecessary.

Dust is common to all air. Warm air deposits dust abundantly on cooler surfaces, hence rooms mechanically ventilated usually shew discoloration on walls near the inlets.

A paradoxical observation by Haldane that the micro-organisms become less numerous in occupied rooms is explained by the trapping which takes place in the respiratory tract. So, too, gas flames burn it, and cremate micro-organisms.

Contrary to general opinion dust in air as a source of disease is practically negligible in school-life. For school purposes from half to one million particles in the cubic foot, when the deposit is counted with a two-thirds inch objective, is comparatively unimportant.

In the Report of the New York State Commission these amounts were frequent in unwashed school air; it was noted that the quantity of dust bore no relation to the judgment of comfort or stuffiness in rooms. Micro-organisms, too, appear less important than usually held. Dust in the air increases with sunshine.

Winslow and Baskerville in New York schools with window ventilation only isolated ten mouth streptococci out of 30,000 colonies on 750 plates.

In the Commission (N.Y.) enquiry, out of 868 cub. ft. examined

only thirty streptococci occurred in every 100 cub. ft., which is rather over the daily school quantum of air breathed. Indeed, in either London or New York it requires a large sample of air to detect these organisms, and they are considerably in excess of other pathogenic forms, so that it needs enormous amounts to be handled to detect even such a common organism as the colon bacillus.

The risk of a child being directly infected with disease through the air it breathes is negligible. Infection is a physically sprayed, and not an air-borne contagion (Chapin, *Journ. Am. Med. Ass.*, 1914. i. 23).

The particular factors likely to be met in school-life, which, within the range of probability, are of no account, are oxygen, carbon dioxide, animal toxic products, odours, micro-organisms, and the usual dust.

Generally, the chemical composition of the atmosphere within any likely variation of respiratory impurity does not matter, and may be neglected in questions of ventilation.

The Things that Matter in Ventilation.—As explained in the chapter on Nutrition, the process of living is a continuous oxidation. The end products are oxygen taken in, and carbon dioxide given out. In addition to carbon dioxide there is a certain quantity of water and also heat.

Each human being gives off about 0·6 cub. ft. of carbon dioxide hourly, from the ordinary metabolism of living.

Corresponding to the chemical changes thus indicated is an amount of " heat of combustion," roughly about 400 British Thermal Units. The B.Th.U. is about one-quarter of the large Calorie, here used as the unit generally applied in engineering practice. It is the amount of heat required to raise one pound of water through 1° F.

Tigerstedt (Nagel, *Handb. d. Physiol.*, 1909. i. 557) worked out this heat production in its various sources—

Heart	70 Calories
Respiratory muscles	150 „
Liver	368 „
Kidneys	74 „
Skeletal muscles	1000 „
	1662 Calories

The estimates of heat given off vary from 366 B.Th.U., Attwater's value, to 495, Flügge's value. The average is about 400 B.Th.U. hourly for adults.

The New York Commission from Benedict's laboratory took the heat output of children as rising from 300 B.Th.U. between 7 and 8 years of age to 500 B.Th.U. at 13 years, and then falling again to 464 for a young adult.

The removal of this heat from the body is as important as the removal of carbon dioxide. It was the practical indications and deductions of Haldane which gradually excluded the unimportant chemical variations, and insisted on the weighty thermal ones. He shewed that continuous work becomes impracticable with a wet bulb temperature of 78° F., and impossible when this reaches 88° or 89° F.

Ventilation is a problem of physics, not of chemistry.

The school child needs to part with 300 to 400 thermal units hourly. It does this mainly by the skin, partly as latent heat of evaporation, and partly by raising the temperature of the mantle of air and aqueous vapour in contact with the skin.

This heat removal through the skin constitutes the purpose of ventilation, a physical function of air important for life. It is quite distinct from respiration, the other vital function, on which depends the chemical changes of metabolism, and which is carried out through the lungs.

The writer tabulated these functions in a diagrammatic way side by side (*School Hygiene*, 1915. 123).

Table 100.

PHYSIOLOGICAL FUNCTIONS OF ATMOSPHERIC AIR.

Respiratory.	Ventilatory.
1. Through the lungs.	1. Through the skin.
2. Independent of physical condition of air, within wide limits.	2. Wholly dependent on the physical condition of the air.
3. Dependent on chemical composition, i.e. oxygen pressure must exceed 12 per cent. of an atmosphere.	3. Independent of the ordinary composition of the atmosphere.
4. Cannot be substituted by water.	4. Can be replaced by a cool water bath.

The ventilatory function is not carried on wholly through the skin. The mucous membranes by warming the air passing over them or by passing off latent heat of evaporation in moisture from their surfaces also have a ventilatory action. It is, however, not more than a tenth of the total.

Corlette (*Med. Journ. of Australia*, February 17, 1923) calculates that 10 per cent. heat loss is by respiratory tract, 87 per cent. through the skin, 3 per cent. by other means.

The removal of this 300 or 400 thermal units hourly without discomfort is the problem of ventilation. The fine cutaneous network of nerve endings must not be chilled, or unpleasant subjective sensations and reflexes are set in action. The skin temperature should be maintained.

The skin, however, can become accustomed to wide variations of temperature. Children spend hours in the sunshine among the snow at Leysin without clothing beyond shoes and loin cloths.

English scholars work best at 58° F., whilst New York schools are required to maintain a temperature of 68° F., and offices and other rooms in New York buildings range from 70° to 80° F.

If the skin is not to be unpleasantly affected, much heat should be removed as latent heat in evaporated fluids. The amount of heat lost in this way does not seem to have been very thoroughly studied, but it is stated that normally about one-twelfth of a pound of water is lost hourly by insensible perspiration. This would account for about one-sixth of the heat loss. It is probably a direct "tissue vaporization" without actual perspiration.

The remaining heat escapes through the skin, and heats air and vapour in contact with the surface. Hourly it is sufficient to raise the temperature of 2500 cub. ft. of air through 5° F.

Heat Removal.—There is a great reserve possibility of losing latent heat in evaporation, for over and above that lost in insensible perspiration, if actual obvious perspiration is produced, very much greater amounts of heat can become latent, and this reserve comes into play with raised air temperature.

Dampness and external temperature vary in their effect according to whether the mantle or layer of air in contact with the skin is disturbed by ventilation.

In quiet air Steinhaus attempted to measure the effect of heat, and got results agreeing with Rubner. The skin is maintained about 89° to 91° F., but if owing to dampness and warmth its temperature is raised, whilst at 92° F. it feels agreeable, by 94° F. this becomes intolerable (*Zeit. f. S.*, 1913. 22).

The reduction of skin temperature by chilling has been studied by Kellaway and Stiles. In cooling the external air down to 70° F., the skin temperature only slowly comes down by 4° to 5° F. Beyond this the skin temperature rapidly falls degree for degree till the external temperature is about 57° F., when the skin temperature is again only slowly reduced below about 70° F. It is in the sudden fall that the risk of chilling and reflex congestions probably comes in with passive subjects (*Am. Phys. Ed. Rev.*, 1914. 215).

Blagden and Fordyce (1775) long ago noticed that their mouth temperatures did not arise above normal when remaining fifteen minutes in a dry room heated to from 115° to 126·7° C., although the heat was sufficient to cook a beefsteak. Exposure, however, for the same time in a moist room heated to 54·4° C. caused the body temperature to rise to 37·8° C.

When sweating is delayed, or arrested, sufficient heat removal does not take place, and in a hot climate there is danger of heat

stroke. With this threatening, the correct treatment is to spray the surface of the skin with water, and fan it vigorously to evaporate the water, thus producing an artificial sweating effect, which removes heat as latent heat of evaporation.

It is obviously an advantage for heat removal that air in contact with the skin should be as cool as can be comfortably borne, and dry enough to take up moisture readily without causing desiccation.

In the English climate under normal conditions, drying or moistening of air artificially can be neglected as of little practical importance. Moist air is lighter than dry air at the same temperature, as aqueous vapour only weighs five-eighths of the air it displaces, so that there is a tendency to upward movement of the film of air in contact with the skin. This is added by its increase in temperature. The relative movements of the air or individual are more effective in helping to keep continuous contact of the skin with cool and unsaturated air, which is the aim of all ventilatory devices.

The physics of the problem formed the basis of a paper by Professor Barker at the Society of Engineers in May 1915, in which he attempted to separate the factors of convection and radiation, and shewed the necessity of separating ventilation and warming.

The important alteration of air used up in ventilation is the addition of aqueous vapour, the disappearance of the latent heat of vaporization in its production, and some increase of temperature. Speaking generally, the change which unfits air for ventilation is physical change of a diminished capacity for taking up heat.

It is evident that either heating or moistening the air beyond certain low amounts mainly destroys its physiological effects in ventilation, and that to supply hot or damp air, however pure and clean chemically, for ventilation purposes is as reasonable as offering a thirsty man salt water to drink.

For comfort, external heat is needed to prevent a sensation of chill from rapid cooling of superficial nerve endings in the skin, and should come as radiant heat on the surface. The warming of rooms must therefore be entirely separate from air supply for ventilation.

The warm walls remain clean, as dust does not deposit from the cooler air. The air supplied being required as cool as the skin can comfortably endure should never be used for carriage of heat to warm either buildings or furniture. As a matter of economy the specific heat of air is so low that when air carriage of heat is used large volumes of air have to be used, and great quantities of heat are thus extravagantly carried into the outer air. Mere coolness of air is an advantage. Leonard Hill in many lectures and

papers has demonstrated the enormous importance to general health of living in such cool and moving air.

Although the effect of ventilation results in a diminution of the specific gravity of air used, so that each individual may be looked on as his own ventilating machine, yet this "chimney effect" is small, and other means of moving the air have to be adopted.

The methods which incidentally give the worst results chemically, and bring out the full *bouquet d'enfant*, are the so-called natural or gravity systems, dependent on the weather and windows. In the English climate they are wholly insufficient for school purposes with a floor space of less than 15 to 20 sq. ft. per head.

Recent school efforts at improving these methods all try to get potential space increase by largely opened windows, as in Reid's Staffordshire schools or the Derbyshire buildings (p. 747).

The other advantages of a class-room on the 10 or 12 ft. sq. basis can only be beneficially employed if mechanical ventilation with cool air is adopted, without this the children are bound to suffer in health.

In all English schools seen by the author where mechanical ventilation has been used, the air, but for its dryness in spite of wet filters and its movement, would have been almost useless for ventilation. The moment movement slows, through short circuiting elsewhere, there is a cry out for more air. Owing to heating and ventilation being combined, the air is physiologically almost destroyed before being delivered in class-rooms. So bad is this matter of overheating in some cases that Winslow notes a thermometer reading to 130° F. having been burst by the air entering a New York class-room (Winslow, *J. Am. Med. Ass.*, November 17, 1914).

The things then that matter in ventilation are—

(*a*) *The capacity of the air to take up heat* either by actually becoming heated, or by taking up latent heat in evaporated water.

(*b*) *The movement of the air* to carry heat off and prevent local heat saturation.

For comfort there is also necessary—

(*c*) *Sufficient radiant heat to prevent chilling* of the skin surface.

These physical properties are estimated on the temperature of the air. The most suitable is about 55° to 62° F.

The humidity is estimated by the reading of the wet bulb thermometer.

Dryness of Air.—In cold weather, when the vapour pressure of the outside air is low, if air supplied to rooms is heated it becomes excessively dry, unless well wetted by passing through moist screens, after heating. The writer has seen charts and diagrams in a school all buckled and curved, standing out from the walls, owing to excessive dryness of air when thus used to carry heat.

With the overheated atmospheres in North America this dryness becomes almost a nuisance. Hot-air comfort is the term used by Hubbard (*J.A.M.A.*, 1925. ii. 1022) in discussing the overheated conditions there. In 1820 Americans were like other folk in the sanitation of air. The hospitals even there were to be "not below 50° F. or above 60° F." In those days heating was mostly radiant from the open fire. He traces the dry air as the cause of overheating. Saturated air at 100 has about the same heat convection (effective temperature) as dry air at 300. Americans are trying to use dry air and developing a hot-house habit. Air at 20 per cent. humidity, as in American rooms, desiccates food, complexions suffer, and even furniture. The aridity of school and living-rooms is such in winter that it rivals the dryness of the deserts, and is a cause of chronic congestion of the nasal surfaces. This sense of dryness is found to be dependent on rate of movement of the air, and is more evident when there is a steady constant flow as on the plenum system, than where there is intermittent variable flow with open windows. Count Rumford, a century ago, suggested that heated German stoves roasted the dust, and produced the unpleasant stuffiness of the domestic heating there.

Dryness of the throat, worked at for many years by Professor Nussbaum of Hanover, is attributed by him to the same cause, from products of dry distillation of dust, through warming surfaces being heated above 160° F.

His experience also shewed that the subjective feeling was independent of actual humidity, and even worse in moist air (*Int. Congress f. Schulhygiene*, Nuremberg, i. 325).

Relative humidity by itself is not always a criterion of dryingness, nor of the sensation of dryness, other factors as velocity and temperature coming in.

Determination of CO_2 Present.—The general examination of air as regards its chemical constitution is a technical chemist's work. The carbon dioxide content, if examined in reference to the outside air content, however, is comparatively simple. The method described as Angus Smith's method in many text-books of hygiene, measuring the largest bottle of air in which a half-ounce of lime-water may be shaken without becoming milky, is awkward, clumsy, and untrustworthy for practical use.

A simple method is to choose a white-tinted stoppered Winchester quart bottle. It is filled with an outdoor sample of air by pumping with a bicycle pump. A little phenolphthalein solution is added as an indicator, and then from a burette several cubic centimetres of a baryta solution about 0·5 gram to the litre is run in till the indicator is tinted red. The stopper is then inserted in the bottle, and it is shaken till the colour goes, more baryta is added, and after some time the colour is permanent. The number of cubic

centimetres used is the standard of CO_2 in outer air. The process repeated elsewhere gives the CO_2 in this selected place, in terms of that in the outer air.

By using several bottles and burettes and a relay of boys to fill them with air, and to shake them, many determinations can be done rapidly and with sufficient accuracy for school purposes.

For more accurate work, Haldane's apparatus is unsurpassed. Samples of a few ounces of air can be taken in stoppered bottles and tested later in the laboratory (*Journ. of Hygiene*, 1904). Formerly this determination of CO_2 was held to be very important, now it has become a matter almost of indifference for ordinary school purposes.

Temperature and Humidity.—The temperature of the air is taken by ordinary thermometers.

Wet bulb reading, as already indicated, is of great value. The readings are more reliable if the wet bulb thermometer is whirled at the end of a cord to promote evaporation. With an air temperature in the class-room between 52° and 62° F. the wet bulb thermometer should read 5° or 6° lower than the dry bulb. The nearer the two readings are together the more humid the air. The relative humidity, or percentage humidity as it is generally stated, requires for its determination the vapour tension of aqueous vapour at the dew point.

Very roughly this is as much below the wet bulb as the wet bulb below the dry.

If centigrade temperatures are being used, t being the dry bulb and t_w the wet bulb temperatures, the saturated vapour pressure at $t°$, the dew-point is found from the formula $f(t - t_w)$. This factor f is given in the following table—

TABLE 101.

Temperature.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
° C.										
−10	8·76	8·73	8·55	8·26	7·82	7·28	6·62	5·77	4·92	4·04
0	3·32	2·81	2·54	2·39	2·31	2·26	2·21	2·17	2·13	2·10
+10	2·06	2·02	1·99	1·95	1·92	1·89	1·87	1·85	1·83	1·81
20	1·79	1·77	1·75	1·74	1·72	1·70	1·69	1·68	1·67	1·66
30	1·65	1·64	1·63	1·62	1·61	1·60	1·59	1·58	1·57	1·56

For ordinary barometer pressure Apjohn's formula for 30 in. gives the value nearly enough.

Vapour tension at dew-point $= f - \frac{D - W}{87}$, f being vapour tension at wet bulb temperature, and D and W the readings of Dry and Wet bulbs respectively (in Fahrenheit degrees).

The relative humidity H is then—

$$H = \frac{\text{Vapour tension at dew-point}}{\text{Vapour tension at dry bulb temperature}}$$

and if saturation is 100, then 100 H is the percentage humidity.

The tensions generally used are in Fahrenheit degrees and inches of mercury.

TABLE 102.

TENSIONS OF AQUEOUS VAPOUR AT VARIOUS TEMPERATURES.

Degrees, Fahrenheit.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
30	0·167	0·174	0·181	0·188	0·196	0·204	0·212	0·220	0·229	0·238
40	0·247	0·257	0·267	0·277	0·288	0·299	0·311	0·323	0·335	0·348
50	0·361	0·374	0·388	0·403	0·418	0·433	0·449	0·465	0·482	0·500
60	0·518	0·537	0·558	0·576	0·596	0·617	0·639	0·661	0·684	0·708
70	0·733	0·759	0·785	0·812	0·840	0·868	0·897	0·927	0·958	0·990

* Watt's *Dictionary of Chemistry*, iii. 231.

There are many Continental varieties of the hair hygrometer, but none is used in English schools.

The movement, intermittent and local, by which surface layers of air in contact with the skin are continually changed and renewed, preserves their capacity of taking up heat, and prevents them becoming saturated with heat and moisture. They are extremely important physiologically, yet difficult to assess physically.

The Kata-thermometer.—Leonard Hill has endeavoured to construct an instrument, which in its earliest forms might be roughly regarded as a kind of artificial human body from its reactions to the above physical qualities. It has become simplified into the special use of a large alcohol thermometer, the kata-thermometer, with a stem about 20 cm. long, graduated about the middle third in tenths of a degree from 100° to 95° F.

The bulb is about 4 cm. long and 2 cm. diameter. There is a safety expansion bulb at the top of the stem. The thermometer is used by being heated above 100° F., then transferred to the place to be observed, and the time it takes to fall from 100° to 95° F. is noted. This gives a measure of the heat absorbing capacity of the atmosphere.

For each instrument there is a Kata factor (K), this is $K = 0{\cdot}27\ (36{\cdot}5 - t)\phi$, where ϕ is the time in seconds which the kata-thermometer takes to fall from 100° to 95° F. in still air at temperature t° C. The 36·5° C. is the average temperature centigrade of the thermometer during the time observed, and is used, as then the kata factor divided by the time in seconds taken in

falling from 100° to 95° F. gives a result corresponding to the cooling power in millicalories per square centimetre per second. The instrument can be used dry when it measures rate of loss or gain of heat by radiation and convection, also expressed in millicalories. It may also be used as a wet kata. A finger stall of a Lisle thread glove is drawn over the bulb. The thermometer is heated in hot water, and when hot enough removed, shaken thoroughly to throw off superfluous water, and set for observation of time in falling from 100° to 95° F. The wet reading gives the heat lost by radiation, convection, and as latent heat of evaporation. Where F is the maximum vapour pressure in milli-

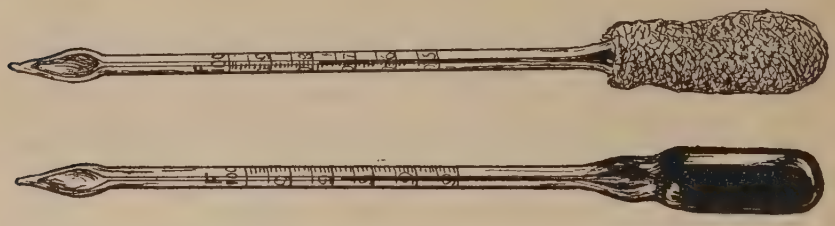


Fig. 147.—LEONARD HILL'S KATA-THERMOMETER.

metres of mercury at 36·5° C., i.e. the surface of the wet bulb, and f is the vapour pressure in the air, the heat lost is

$$H = 0{\cdot}27\ (36{\cdot}5 - t) + 0{\cdot}085\ (F - f)\ \tfrac{4}{3}$$

The difference between wet and dry kata gives the rate of evaporative loss of latent heat—

$$E = 0{\cdot}085\ (F - f)\ \tfrac{4}{3}$$

The kata-thermometer is a most convenient and sensitive instrument for slight movements of air indoors, as it integrates eddies and small movements of all kinds. For a wind velocity greater than a metre per second—

$$E_1 = (0{\cdot}13 + 0{\cdot}47\ \sqrt{V})\ (36{\cdot}5 - t)$$

For wind velocities equal to or less than a metre per second—

$$E_1 = (0{\cdot}20 + 0{\cdot}40\sqrt{V})\ (36{\cdot}5 - t)$$

where E_1 = millicalories per second per square centimetre,
V = metres per second,
t = degrees centigrade.

Hill states that the cooling power for sedentary workers should be at least 6 for dry and 18 for wet kata readings, and for active workers these readings should be increased. Barwise, in the floor-

heated Derbyshire rooms, used 7 and 20 as necessary. Dr. Simpson, in Torquay, has confirmed these values, and shewn that in practice the kata corresponds better to subjective records than any other measure. In variable climates with heat and damp and dryness it may be of the greatest service. Using the 6 and 18 standard the medical officer for Natal shews that up-country schools are below ventilation standard in half the cases, and that 63 per cent. of the rooms in Durban schools were wanting. He asks for a more open type of school, especially in the coast regions.

This instrument has added enormously to the power of examining the condition of air in respect to ventilation, as it integrates all effects, positive and negative, giving a result concordant with the ventilation effect on the body.

The evaporative effect was also estimated by the New York Commission by means of the atmometer, a porous cup arrangement by which, from amount of water evaporated, the dryingness of the air is measured (Palmer, *J. Am. Heat and Vent. Engin.*, July 1917. 525). This shews that dryness is not dependent solely on humidity. School-rooms standing highest in evaporative power are humidified fan-ventilated rooms with 38 per cent. humidity, which evaporated 40 per cent. more water than window ventilated rooms with 28 per cent. humidity. The difference being due mainly to the steady movement maintained by fans.

Popularly, dry air is supposed to be a cause of nervousness, restlessness, and lack of effort, but these results are almost entirely reported from America, and probably due to overheating of air.

Humidity has been investigated in mechanically ventilated schools by examining humid rooms and control dry rooms.

In the West Schule in Jena, the effect of pans of water placed on the radiators in air ducts was found to be trivial, and it was decided after experiments in which some rooms were supplied with humidified air, and some with non-humidified, that no gain came from increasing water supply, and that the children were so crowded, with approximately 11·5 sq. ft., that neither through radiation nor convection could they get rid of their heat, and that dry rather than moist air was needed; that any errors in ventilation were independent of humidity, but depended on excessive temperature (*Zeit. f. Schul.*, 1909. 77).

A similar enquiry was carried out in America (*Boston School Report*, 1913, Appendix X) in a three-storied school with two wings, which were alternately used as controls, the air supply being 1800 cub. ft. per head per hour. No differences in mental work were noticed, but conclusions as to comfort were that in humid rooms 5° F. difference was more obvious than in dry rooms, and that air should never be moistened over 40 per cent. With a temperature at 70° F. it is better not moistened at all.

The New York Commission tested two classes for sixteen weeks. They alternated them a month at a time in their rooms, but one class was always humidified, the other dry. The amount of air supply was 2160 cub. ft. per head per hour in both cases. The nett floor space was 14·5 sq. ft. The temperature differences only averaged 0·7° F. The humid rooms averaged 42·3 per cent., or 13·6 in excess of the others. The dryingness of the dry rooms was 21 per cent. greater. Carbon dioxide content was the same in both. In the regularly recorded judgment of teachers, the humid rooms were stuffy nearly a quarter of the time. Odour was occasionally noticed, always in the humid rooms; they often smelt damp and close. Except that nasal breathing was a little better in dry rooms, no significant physical bodily changes were noted, and there was no difference in mental work or progress of the children. The chief difference was increased cost, 2·7 times of current for humidification.

The New York Commission concluded that artificial humidification does not produce any striking improvement in health and efficiency of school children, and that it makes air less, rather than more, attractive from an æsthetic standpoint.

As regards the English climate, unless the air is heated excessively, moistening air for the purpose of humidification is to be regarded as unnecessary expense.

In American schools, if heating of the air is dispensed with, the humidification will become a trivial problem.

Class-room Ventilation.—School ventilation is the most difficult of all ventilating problems. The child itself requires proportionately more heat removal than the adult, and in English elementary schools the crowding is so great that children are in actual contact with a neighbour. Haldane states, and it is specially applicable to school-rooms, that in crowded places the best means of improving ventilation is to increase the floor space per head.

Teachers are often ignorant of sanitary and hygienic precautions. They have had no real instruction. The head master who used a postage stamp to prevent a draught from a hole in a window is typical of a considerable proportion of teachers.

If De Chaumont's test of smell is applied every elementary school in town, and many in the country, will be found defective.

It would be difficult to find schools in London which satisfy the L.C.C. Regulations (March 20, 1923) for ventilation of places of public resort, and many smell offensively on entering.

The most offensive school air the writer remembers anywhere was met on entering a Church infant school during a bright and breezy Autumn afternoon on the slopes of Snowdon.

Methods of School Ventilation.—The various methods of school

ventilation have been classed by Kimball (*Heating and Ventilation of School Buildings*, 1914) as—

1. Natural, e.g. only open air, where no direct warming or ventilation apparatus is used.
2. Direct radiator systems with open windows.
3. Direct-indirect radiators with passage of air through radiators from outside.
4. Gravity (*a*) indirect heating in cellar, and (*b*) extract heating.
5. Single fan systems.
6. Double fan (*a*) without radiators in rooms, (*b*) "split" with room radiators.

Kimball's experience was that the direct-indirect (3) is the most unsatisfactory, and that any system without positive exhaust of vitiated air is likely to be defective. Gravity exhaust, he states, as four or five times more expensive than fans.

The ordinary class-room should be heated with low-pressure hot-water pipes, and possibly it may have a fireplace.

The windows should be able to be opened over at least half their area, and not only by one or two panes at the top.

It is an advantage if there can be a cross draught high up. The Chaddock window is a good school type for wide areas. With such arrangements, and considering the prevalent winds, and the moderate temperature in the British Isles, judicious use of open windows for ten months of the year helps to keep a tolerably cool atmosphere.

The best arrangement of a school window is a large hopper in the lower 2 or 3 ft. of the window, opening inward, to an angle of about 30°, so that the entering air turns upwards. All vanes, muslin, cotton-wool, or fine wire meshes are obstructions and unnecessary. Below the window there should be a heating radiator, the current rising from this to diffuse with that entering through a hopper. In the particular case of laundries it is found that a high up hopper, opening outwards, acts better than one opening inwards.

The experience of the New York Commission is one in which school observers will agree, namely, that school-rooms ventilated by windows alone are unsatisfactory. In cold weather it is necessary to cut down the window openings, heated air accumulates above, cold air enters into a pocket on the floor, and the feet are chilled, whilst the atmosphere grows more and more offensive from stagnation.

These conditions are materially remedied when gravity exhaust flues add their effect. Sometimes, if these are in the ceiling, they simply douche the unfortunate children with cold back draughts. This occurrence should not be common, and can be avoided by providing the duct outlet with a shutter to be used in necessity. This outlet should not be in the ceiling.

The ducts in the N.Y. Commission enquiry were placed on the wall opposite the window, and were of 8 sq. ft. section for a 39 place room with 250 cub. ft. per head, i.e. roughly 20 sq. ft. space per head. This is 30 sq. in. per head outlet.

With a reasonable floor space the ventilating troubles, which have a contributory effect in producing the anæmia and debility so common in the elementary school, will be simplified.

English class-rooms generally should be written down to two-thirds of their present accommodation. This is necessary for healthy environment in regard to ventilation, and to diminish risk of infections. It is part of the tuberculosis tax on civilization (p. 262) which has to be paid, and which there is no evading.

With the natural ventilation found in most schools it is the window ventilation alone which counts most of the time, and is unsatisfactory. Where an electric supply is available a small fan in each room to supplement air movement would make this method of ventilation sufficient the whole year round. It would be cheaper than other means of propulsion, but would not do so well in dusty, noisy town streets where the windows have to be kept shut.

Tobin's tubes, when seen in the corner of a class-room, are remote from window and door, and often receptacles for dust, or in service as stands for books or flower-pots. As inlets they are of scanty value, unless wind happens to blow against their outer ends.

Their area is usually negligibly small, and the gratings or nettings over them, and the right-angle bends in their course, reduce any current through by two-thirds or more. They may be set down as hardly worth the cost of construction, but where they are supplied the tops should be sloped at 45° to prevent their use for other purposes than ventilation.

Experience is that although a fireplace and chimney seem inadequate in the volumes of air they pass, yet by promoting local movements, and especially when fires are supplied acting as outlet ducts, they contribute to improve movement of air in window-ventilated rooms.

The Board of Education Regulations, 1914 (Cd. 7535), state in regard to secondary schools: "16 (*b*). Windows of the ordinary type on one side of the room only, with some form of extract in the chimney or ceiling, and inlet tubes in the walls can no longer be considered as providing the best form of ventilation for a class-room," is very unfortunately worded, for window ventilation with gravity exhaust, was found to be one of the best systems by the N.Y. Commission. These secondary schools are on a basis of 16 sq. ft. at least, and should do well with the system condemned above if the windows are properly used. In contradistinction, all 10 sq. ft. per head rooms, which are hygienic scandals, and all

rooms where on account of dust or noise the windows must be kept shut during school hours require ventilating mechanically through ducts, either inlet or extract or both.

Need for Fans in all Schools.—Cost in building is mistakenly saved on ventilation. Ducts are rarely built large enough, and this cannot be remedied later by more powerful fans after the building is put up. The attempt means waste of engine power for little improvement.

The school doctor who has to look to ventilation in a new school should see to large duct space. Where unheated air is used the duct space can be reduced, and for existing schools with too small duct area reduction of heat carriage by the air, and the substitution of radiators in the class-rooms, will give a satisfactory but costly solution; class-room electric fans where possible would be cheaper.

The head of air should be got by both propulsion and extraction fans for the best results. Doors and windows can then be opened freely. It would pay to distribute power thus rather than concentrate it entirely on propulsion.

Again, "no hot air in school" must be insisted on. Mechanical ventilation is wasted expense if the air is used to warm the building. A safe rule is that the entering air should be 10° to 15° F. below the room temperature, and no air should ever be warmed over 62°, or after washing. Architects and engineers are great offenders against both physics and physiology in regard to using heated air.

Washing is advisable for partial cleansing of the air from micro-organisms and dust. These germs are generally non-pathogenic, mostly simple moulds of a harmless nature. Washing also helps to cool air which takes up moisture in the process.

A common arrangement for a mechanically ventilated school is the plenum system, where doors and windows have to be kept closed to maintain the proper distribution of the air in the building. The air pressure in the building being above that outside gives the term "plenum."

In England open-bladed low-power fans are used, but in America high-power blowers are general. Low-speed fans are less noisy, and in any case noise from the fan has to be guarded against. The air is usually drawn in at the street or yard level, passes through a washing screen of coke or coarse canvas or jute strips over which sprays of water fall. Sometimes the filter is stretched over a cylinder of wooden laths which rotates slowly on a horizontal axis with its lower portion in a water trough, to cleanse and moisten its surfaces. These washing filters should have small tempering coils in front for use to prevent freezing in cold weather.

The air next passes through the propulsion opening, in which plays either an open-bladed fan or a blower. After this it is heated in most systems by passing over coils and radiators.

This is the fundamental mistake of every plenum system the writer has inspected. The heating should be omitted, or at least reduced to such an extent that no air exceeding the normal 62° F. is delivered in any room. Rooms must be warmed by separate heat convection, not air. Heating it after it has been moistened means reducing the relative humidity to considerable degree. In England for nine months of the year, if both heating and moistening were omitted, the air could be delivered at a much less velocity with great advantage.

In cold weather the heating should just bring the air to 62° F., and heating surfaces in the ducts to do more than this are harmful.

The ideal has been to deliver air in class-rooms about 30 cub. ft. per head per minute ; for cool air this is unnecessarily high, if sufficient floor space is provided.

In investigating the movement of air from a duct the anemometer must be moved about the whole time to cover equally all parts of the inlet as velocity varies enormously at different levels of the inlet. Several readings must be taken and averaged. The average velocity thus found, multiplied by area of the inlet, will give the volume of air delivered.

The old criterion of volume of air required depended on the carbonic index being kept down. The physiological criterion depends on the amount of heat removed. A child gives off enough heat to raise the temperature of 2500 to 3000 cub. ft. of air by 5° F. This represents the volume of air required. If air is delivered sufficiently cool volume may be reduced, with proper heating arrangements, more especially guarding in window-ventilated rooms against cooling of the feet and legs ; 1500 cub. ft. an hour should keep the temperature within reasonable limits, so that there is sufficient heat removal all the time.

Gordon, in his work at the House of Commons, states that testing air between 55° and 60° F. the movement of 1½ ft. per second is not felt, 2½ ft. just perceived by very sensitive people, and 3 ft. distinctly by most.

These class-room velocities should never occur except at the actual inlet.

One of the last occasions on which the writer had to deal with complaints as to ventilation was in January 1914, when he concluded a Report by stating—

> " Ventilation has been dealt with exhaustively in the Reports of the Medical Officer (Education) from 1902 onwards. The conclusions there given have been confirmed by subsequent workers, and even in details by the enquiry of the City of Boston School Authority, so that they are now almost universally accepted.
>
> " The chief factors for the definite solution of the problem

of school ventilation are known, and were worked out in the London schools in 1902 and 1906. They may be concisely put in the statement that air should be supplied at a sufficiently low temperature and humidity, and in such movement, that without unpleasantness about 80 calories of heat are hourly taken up from each of the children.

"As has been frequently pointed out since 1902 . . . (a mechanically ventilated) school can never be satisfactory from the ventilating point of view until there is a separate carriage of heat to the class-rooms apart from the air supply. The air is physiologically impaired, 'canned air,' by its temperature.

"All other matters in connection with the ventilation are trifling and unimportant in comparison with this."

Yet such schools go on unaltered, debasing the health and nutrition of both children and teachers.

The feelings of comfort, however assessed, appeared to New York reporters to be greatest in cooler rooms, whether window or fan ventilated. Other things being comparable, it seems that a much less active general air movement accompanied by minor slight fluctuations, as in window, contrasted with fan ventilation, is actually more agreeable and more stimulating to the vasomotor system

Gordon states that comfort is assured with wet bulb reading below 60° F.

Duct inlets are usually placed about 2 or 3 ft. from the ceiling, and the duct section at its narrowest part should allow a minimum of 20 sq. in. per head. The common arrangement is to have an inlet 8 or 9 ft. above the floor on the wall facing the children, and well to the window side, not more than a third the distance from the window, and a larger outlet at floor-level in the same wall, but well to the other side of the room.

This arrangement was arrived at after experimental work on models by A. P. Marble (*Sanitary Conditions of School Houses*, U.S.A. Bureau of Education, No. 3. 1891). He used outlets of double the inlet area, and paid especial attention to local change of air at breathing level.

Minnesota regulations require 1 sq. ft. duct area for every 9 persons in gravity systems, and 1 sq. ft. for every 15 persons in plenum systems (1910).

The inlet area at the wall surface should measure twice the height vertically of the horizontal depth of the duct to allow for dead spaces where the air hardly moves at the outlet. The grating over the outlet should be a comparatively large mesh to diminish resistance.

Where rooms are gas-lit, on account of the additional heat in Winter, alternative outlets should be provided high up in the wall, with shutters permitting them to be opened when required.

Although these are architectural details, the doctor must know something of them to pursue school enquiries with success.

Recirculated Air.—On the suggestion of Dr. Luther Gulick in 1911, Flügge's experimental work with fans was carried into practice on a large scale, by recirculated washed air at the Y.M.C.A. Gymnasium in Springfield, Mass. It was stated that no subjective differences could be detected, whilst the fuel saving amounted to nearly 50 per cent. Air was used as cool as 51° F., and the hardest students found it invigorating. By voting on conditions gaining most approval "especially good" votes was given to air between 51° to 55° F., and the number of such "specially good" votes diminished steadily with rise of temperature.

The method was tried in schools. The N.Y. Commission studied recirculated air under these varied conditions. The air before being recirculated is cooled about 15° F. by washing. Dust counts were much reduced by this. Their observations, however, were inconclusive as regards the gymnasium.

In schools, odour was more noticeable with recirculated air, which also tended to get warm and moist. Ozone, when used in various strengths, tended to add its own flavour without removing the *bouquet* already present. The combination was sweetish and unpleasant.

They concluded that whilst for the lower temperatures of the Springfield Gymnasium recirculated air was economical and unobjectionable, yet under ordinary temperature conditions of the American class-room, although the health of children was unaffected, the æsthetic qualities of freshness and absence of odour were strikingly absent, and use of ozone here was a failure.

In London enquiries in regard to fatigue in 1906, where carbonic acid varied from 6·0 to 64·5 vols. per 10,000 it was concluded on the basis of general observations and reckoning experiments that—

1. Mental alertness and accuracy is improved by two or three hours of school-work provided the atmosphere is satisfactory.

2. Temperature above 65° F. gives rise to definite subjective symptoms; slackness and inattention in some, headaches in others. It is not easy to assert definite mental alteration till about 70° F.

3. Symptoms do not appear at 65° F. if air is kept in gentle movement by a fan in the room. At higher temperature symptoms and mental conditions are ameliorated by such movement of the air.

4. With temperature 70° F. and above, other factors being normal, there are evident deteriorations in mental alertness and accuracy.

5. Relative humidity does not affect mental capacity of children at low temperatures. Increase of humidity appears to increase effects of high temperatures.

6. Carbonic acid gas in considerable excess, although not producing the symptoms found in a hot and close atmosphere, seems to produce, after a time, considerable fatigue in the performance of mental functions by children.

This last, paragraph 6, however, is not borne out by the text of the Report, which states that " in the usual concentration CO_2 seems to exert no appreciable effect on mental capacity ; above 35 or 40 parts, this may not be true " (*Report*, 1907. 58).

These results were obtained with young children in primary schools. The N.Y. Commission worked with older children and young adults, and used many refined methods, and investigated every point at great cost, but unfortunately only worked between 60° and 86° F., and mostly got negative results in actual working capacity; it was the inclination to work which was affected. Vasotone was definitely affected.

The Crampton index (p. 73) decreased progressively, 35 for hot (86° F.), 45 for warm, and 60 for cool. Bodily temperature which was lowered by the confinement at 68° F. was raised at 75° F., and distinctly increased at 86° F. In face of this mental work ought to have been affected.

Dr. William H. Burnham wisely suggested that when discipline goes wrong, one of the first things for the teacher is to look at the thermometer. " It is usually better to improve the discipline by letting in fresh air than by the use of sarcasm or the rod " (*Pedag. Sem.*, December 1919. 311).

Respiratory Effects.—The Chicago observation, that warm, dry air makes children dull in contrast to warm, damp air is not in accord with the London observations, and was not borne out by the accurate tests of the N.Y. Commission.

In Boston, where the subject has been well observed for many years, Harrington (1910) states that " all observations shew a direct relationship between anæmia, nervousness, headaches, and recurrent colds and overheated, baked, devitalized room atmosphere," but his published figures are unfortunately defective in data for reducing them to comparisons.

Dr. Josephine Baker quotes (*Med. Record, N.Y.*, April 27, 1918) some of the work done for the N.Y. Commission on the incidence of respiratory disease.

About 5500 children in 76 class-rooms were observed in two periods (Spring and Winter). Children in class-rooms with closed windows and ventilated by mechanical methods were 98 per cent. more subject to respiratory diseases, severe enough to keep them from school attendance, than children who were in class-rooms at the same or lower temperature and ventilated wholly by open windows.

Many popular comparisons between effects of outer air as contrasted with hot living-rooms are to be explained by density of population affording increased opportunity of contagion.

An enormous amount of work has been done on respiratory diseases and the common cold, which it is not proposed to review.

The work of Cocks for the N.Y. Commission in studying the effect of atmospheric conditions on the upper respiratory tract is of especial value for schools.

Chilling undoubtedly reduced immunity. Many observers have demonstrated reduced immunity to infections in chilled animals. Pasteur, for instance, caused fowls to lose their immunity to anthrax infection by standing them for some time with their feet in cold water.

Cocks studied the immediate effect of various conditions of temperature, moisture, and velocity of air by effects on the covering of the turbinal bones. There is practically no change in pharynx or larynx in going from temperate to hot rooms, but the turbinals swell and affect the stream of air passing. This is measured by the size of dew spots condensed on a metal mirror, held horizontally below the nostrils.

The general effect is that heat produces increase in colour, moisture, and size of the turbinals, and that swelling increases with humidity. For certain occupations, as laundry work, this is of importance, and my experience has been that teachers of laundry work with deviated septa become very liable to sinus troubles or atrophic rhinitis.

Cocks's experiments on effects of draughts, by fanning air on the face, shewed that warm air following cold reduced heat effects ; but that cold air after heat caused swollen turbinals and increased secretion, a condition which seemed favourable to ready infection.

Skin reflexes, tested by the body in one chamber and head in another, or by the feet in hot or cold water, shewed that skin effects were trivial compared with direct atmospheric effect on the nasal mucosa.

In regard to general as contrasted with local effects there was a decrease in hæmolysins after three weeks, in animals kept in hot atmospheres, compared with controls in cool rooms.

The subject is still in an indeterminate state save that continued heat and humidity decrease healthy conditions.

Wider comparisons of climate on metabolism have been set out by Corlette of Sydney (*Med. Journ. of Australia*, 1923. i.), shewing how materially metabolism in Summer and Winter must differ in London, New York, Chicago, and Sydney, simply from considerations of heat loss due to average temperatures and humidity.

CHAPTER XLI

WARMING

Warming of School-rooms.—The purpose of warming in school is to keep the surface of the body free from rapid reduction of temperature, and free from chilling which calls forth from the fine subcutaneous nerve endings reflexes resulting in discomfort, *malaise*, or even illness, such as catarrhs or pneumonia.

It has already been insisted that air in contact with the skin should not be warmed, so that it may remain capable of taking up heat by conduction, convection, or in latent heat of evaporation, at the same time the surface must have its temperature maintained by radiant heat from neighbouring objects such as walls or furniture.

The walls and furniture must be moderately warmed, so that they do not feel cold if touched. The aspect of rooms must also be considered. A south room is generally some degrees warmer than others.

The warming of very small schools is managed by jacketed stoves or by open fires. The last are commoner in the Anglo-Saxon lands than out of them, and are scarcely ever seen on the Continent. Stoves with long flues are forbidden in English schools. Open fires are cheerful and pleasant in special rooms for teachers, doctors, or nurses, but in the class-room their effects are likely to be too local. They are wasteful of fuel, require considerable attention, and especially in lofty rooms cause draughts along the floor.

Fireplaces of the Well-fire or Teale type of grate throw out more heat than others. Use is sometimes made of fires to carry flues round the fireplace, and with an inlet in the outer wall of the class-room above or to one side of the fireplace, to heat the entering air. By this means a quantity of air is drawn in, and warmed as it passes to the room.

Probably the warming is ineffective enough not to destroy its physiological qualities, otherwise the better way would be to use the heating effect to aspirate air from the room, which actually is what the chimney does.

Galton's ventilating stove acts in this way, but the delivery of air from the outside through a warming flue, whether in conjunction with fireplaces, jacketed stoves, or radiators, is not to be com-

mended. The air loses in physiological ventilating value by heating before delivery, depriving it of part of its capacity for heat removal.

In most school-rooms heating is outside the room, generally in a cellar. The heat is carried over the building by convection. It may be carried by steam or hot water under high pressure with temperature far above the ordinary boiling-point.

The only system of heat carriage advisable for schools is by low-pressure hot water. It is not subject to rapid variation, the temperature remains fairly steady, without drying the air, and no great expert knowledge is required for management. In addition, there is no danger from the hot surfaces.

Heating by steam or by high pressure and superheated water is not to be recommended, although in expert hands it may be cheaper. It " cannot be approved " by the Board of Education Regulations, 1914. 132.

Heating surfaces may be dangerously hot unless guarded, and the whole system varies so rapidly that it requires constant attention. Further, hot surfaces are liable to cause the peculiar dryness of lips and throat as a subjective sensation arising from the products of dry distillation of dust.

There are many schools from a dozen to twenty years old where carriage of heat is still entirely by air.

All these the writer would condemn as insanitary. They ought to be definitely refused recognition till a system of heating by radiators has been substituted, and cool air is delivered to the rooms.

Low-pressure, hot-water pipes, although unsightly, distribute heat with great uniformity and are cheap, but those who desire to avoid squalid looking schools will pay for radiators, one of which should find a place below each window. Although radiators do not distribute the heat so evenly, they appear neater, and also help ventilation by setting up more local currents in the atmosphere of the room.

The amount of warming by heating surfaces depends on difference of temperature of air and hot surface. Roughly it may be taken as 1·75 B.Th.U. hourly per square foot of surface for every Fahrenheit degree of difference in temperature between air and surface ; it is generally stated, however, as square feet of heating surface wanted per 1000 cub. ft. of space. As a unit (B.Th.U.) of heat will raise 50 cub. ft. of air one degree hourly, the amount of heat can be determined necessary to maintain the temperature of a room at 60° F., if the outside temperature is at freezing-point, 32° F. A standard class-room may be considered such as has been described as suitable for 35 pupils, with approximate height 12 ft., width 19 ft., length 30 ft., giving a total cubic content of 6840, and a floor area of 16·5 sq. ft. per head.

If 1800 cub. ft. of air per head is provided hourly, and the room is to be kept at 62° F., then supposing outer temperature at freezing, 32° F., heat has to be found to raise 63,000 cub. ft. of air 30° F. hourly. As a B.Th.U. will raise 50 cub. ft. 1° F. hourly, it means $63{,}000 \times 30 \div 50 = 37{,}800$ B.Th.U. A square foot of heating surface gives off about 1·75 B.Th.U. hourly for each degree of difference between the surface and air; if the surface is at 152° F. the difference is 90°, and each square foot gives off 157 B.Th.U. hourly. The amount of surface required is therefore 241 sq. ft., or 35 sq. ft. per 1000 cub. ft. A 4-in. pipe has a surface of about 1·2 sq. ft. for each foot of length, so that roughly 5 ft. of pipes is required for each child in wintry weather.

Twenty years ago the usual provision was about 10 sq. ft. per 1000 cubic content. It has steadily crept up with the demand for more ventilation, till now it is about 30 sq. ft., which is sufficient except in extreme weather.

In the example above, 30 sq. ft. per 1000 cub. ft. would have kept the room at 57·5° F., an excellent temperature, and it would have needed several degrees below zero outside to reduce room temperature to 55° F.

The Board of Education Regulations (1914) state that where rooms are ventilated by windows on both sides a warming surface of 25 to 30 sq. ft. per 1000 cubic content will be necessary.

Another method more satisfactory than usual warming arrangements is heating through the floor. In some Derbyshire schools concrete flooring slabs 2½ in. thick are laid on a concrete grid through which the low-pressure water-pipes pass. The floors are kept at 75° F., with doors and windows open to outside temperature of 43° F., and feet are warmed and the rest of the building kept at a satisfactory temperature without air heating. This is not the wasteful system of the old Romans, who warmed floors by hot air underneath them, afterwards used in the building, wasteful in heat, and also in deteriorating the air.

A thermometer should be hung in each class-room. A useful regulation of the School Board for London was that if the temperature at 9 a.m. was below 55° F. it had to be reported. This was altered in 1903 to the stricter test of 54° F. at 9.30 a.m. Opening of doors and windows which could have been kept closed till 9 o'clock reducing the temperature later.

When by any mischance, accident or official neglect, temperatures fall to 50° F. or below, the children should not be kept in desks, but should be exercised, and put on their overcoats. Teachers complaining of cold in school have only themselves to blame if they suffer unintelligently, as they can always put on extra clothes, can exercise their classes and themselves, and report the class-room as unusable.

Cloak-rooms should be especially warmed by at least 50 sq. ft. of warming area to 1000 cubic content. Many school-rooms are still inadequately warmed.

Sometimes it is a special room with perhaps two outside walls at a north-east or north-west corner of a building, or it may be a room with badly distributed heating. Teachers should keep records of the temperature of such rooms at two hourly periods and report them. Officials often complain that their responsibility is at an end through the excessive opening of windows, but this should be no cause for complaint.

Where economical considerations alone prevail in authority, very little is likely to be done. Postponement raised to a process which is a fine art is the order of the day. The writer has before him pre-War reports on a manual training-centre, where the total cost of installing proper warming would have been £120, and where the daily temperatures for two winter months showed that two-thirds of the time the temperature was below 45° F. For nearly two years, by continually postponing decision by asking for further reports, nothing was done, in spite of obtaining seven different reports from officers. The last recorded temperatures of 38° F. were taken by a special assistant sent for the purpose, and the place remained in *statu quo*. Yet cold fingers are ineducable.

It is difficult to say what a teacher's duty is in face of such a case. The class should be dismissed or exercised in the playground till the conditions were ameliorated. Here the N.U.T. should have established regulations, and support their members in their observation.

There are slight risks of carbon monoxide poisoning causing now and then a case of unconsciousness. Usually it is a geyser in a badly ventilated recess, but any stove burning with the whole length of the fireclay candles red is producing much of this gas. For a case in school, fresh air at once with possibly artificial respiration and warmth is usually all that is necessary. In industrial cases oxygen is also useful.

The last Building Regulations of the Board of Education applicable to both elementary and secondary schools state: " 19. Effective ventilation for the class-rooms (1925)—

(*a*) The need for really effective ventilation and the importance of securing abundant sunlight are now generally recognized.

The older type of building compactly planned with several stories, with a central hall off which the class-rooms open directly, is giving place to single-storied groups of rooms, arranged to let the sun and air into every corner.

(*b*) Windows of the ordinary type on one side of the room only, with some forms of extract in the chimney or ceiling, and inlet tubes in the walls, can no longer be considered as providing the best form of ventilation for a class-room.

Far more satisfactory results can be obtained by placing windows on opposite sides of the rooms, and so ensuring a fresh current of air. Experience has shown that if these windows are so arranged as to introduce the incoming air on a low level and to direct it upwards, and if a really adequate amount of heating is provided, an abundant supply of fresh air can be admitted all the year round. The heating surface will have to be increased above that required in the older type of rooms.

Ventilation.

122. Adequate means for ventilating rooms used for teaching must be provided not only for admitting fresh air during use, but for flushing the rooms effectually during the intervals.

123. The inlets for fresh air should be large and well distributed, and be provided with some arrangement to divert the incoming air from striking directly on the children and teachers.

124. In order to ensure a sufficient movement of the air there should be openings on opposite sides of the room, and these should be into the outside air.

125. Where the rooms are properly cross ventilated, ceiling extracts will not be required.

126(*a*). One of the various economical and effective plans is to have the lower panes of the windows arranged to open inwards as 'hopper' inlets with side pieces, the upper parts of the windows being hung on centres to swing, in order to give as large an opening as possible.

(*b*) The windows should be arranged so that at least half their area can be open at once.

(*c*) They may be arranged so that the whole space can be open.

127. Openings behind hot-water radiators and ventilating grates are useful adjuncts in cold weather, but do not obviate the need for an ample supply of properly constructed opening windows.

128. Combined systems of heating and ventilation in which air raised to a sufficient degree to warm the rooms is used for ventilation are not generally desirable in a school. The stimulating and invigorating effects of fresh, cool air are lost, and the children become accustomed to sit with closed windows.

129(*a*). In buildings of more than one storey the ventilation requires particular attention. (*b*) As far as possible, long trunks and flues for the admission of air, which are difficult to keep clean, should be avoided. (*c*) Outlets opening with chimney flues or ceiling ventilators do not work well without some mechanical aid.

130. Generally, the best results will be obtained by providing ample heating power, and making full use of well-arranged windows to secure cross ventilation.

Heating.

131(*a*). The heat supplied to the school should be moderate and evenly distributed, so as to maintain a temperature of from 56° to 60° in the rooms. (*b*) The amount of heating required should be considered carefully in reference to the system of ventilation proposed, for the full use of fresh-air openings is largely governed by the power of quickly warming the room. Where cross ventilation is provided a single fireplace will be insufficient to warm the room thoroughly. (*c*) Where windows are provided on two sides of a room, 25 to 30 sq. ft. of heating surface per 1000 cub. ft. should

be secured. (*d*) In a large room heated by an open fire, the heating should be supplemented by hot-water pipes on the side furthest from the fire.

132. When the heating is by means of hot water, it should be at medium or low pressure; high-pressure water and steam heating cannot be approved.

134. Slow-combustion stoves with long flue pipes cannot be approved.

135. Stoves should be of a pattern with an open fire, and have proper chimneys into which the flue pipe can be directly taken.

136. Gas radiators or stoves are not approved for warming rooms used for teaching unless they are provided with flues. . . ."

CHAPTER XLII

ILLUMINATION

Educational Necessity for Good Lighting.—The drive in life's activities comes from the emotions, but the control of that drive is through the intellect. The substratum on which the emotions depend lies deep in the history of the nervous structures, and deals with general states of feeling and consciousness. The intellect, associated with the most recently developed cortical layers of the brain, makes comparisons and judgments of things presented by the senses. These cortical layers are the structures to be influenced by formal education. Education in school is too much, and sometimes almost wholly a matter of intellectual activity. The young child is at a hopeless disadvantage in face of the teacher's technique. It cannot grow, it is trained. One of the main avenues of training is through the eye, and this must exercise its powers easily and comfortably. Good illumination is necessary for the distinctions and comparisons on which intellectual judgments and control are built. On the other hand, poor illumination, the "dim religious light" makes such intellectual work difficult to the less educated, and conduces to the outcropping of otherwise subconscious feelings and actions in an intellectual twilight of dreamy, half-conscious states, in which external suggestions, usurping the place of the will and judgment, play too large a part in control. Moonlight does not aid sound judgments, and a first requirement for clear observation in dealing with the objects of education is good lighting. The other kind of activity, the effect of external suggestions is also education, and powerful education, more likely ultimately to control the life, but it is not of the kind which most teachers strive for, and has little to do with the academic successes at which they aim. The cry of the dying Goethe, "Mehr Licht," is still the cry of nearly all our schools. The psychological effect of good lighting, the feeling of comfort and safety inspired is well known to business people, and is one of the big assets of the trade which controls the public-house.

In education, not only the illumination, but the cleanliness and freedom from dust of windows and fittings, so important for the maintenance of good lighting, constitutes a provision which pays, even if estimated on the sordid level of grants earned.

Estimates of Lighting.—If estimates of lighting values are to be assessed properly the final judgment and measurement depends wholly on the effect on the retina.

The value of illumination cannot be expressed in absolute units. The amount of energy in two systems of lighting may be the same, whilst their effect on the eye may be quite different. The response of the eye has already been detailed. The reflex of the pupil contracting sharply on any sudden increase in brightness, then slowly relaxing, evidently means a protective mechanism. The important adaption of the retina by which the nervous terminals are slowly, through many minutes, surrounded with dense pigment when exposed to bright light, and this again equally slowly retracted in dark adaptation, makes the eye an extremely variable means of comparing illuminations. The rate of adaptation is roughly proportionate at first to the change in the illumination, and may make the dark adapted eye in the course of half an hour hundreds of thousands of times as sensitive as when light adapted. The adaptation appears to depend mostly on the central parts of the retina. The periphery not being very variable in adaption remains about the same sensitiveness, nearly dark adapted. On going from daylight into a dark room one may see the face of a luminous watch if this is not looked at directly, but a little to one side, so that its image falls on the retinal periphery. Looking directly at it the image falls on the macula, and cannot be perceived for some time, until the macula becomes slowly dark adapted.

In considering any variety or mode of illumination, the subjective effect in relation to the condition of the adaptation of the eye must always have a definite place, or sound judgment will be difficult. It is a factor in nearly every problem. It is this which explains Waldram's statement that "0·4 foot-candle coming from a dark wall-paper does not necessarily give the same general impression as 0·4 coming from a wall of a lighter shade."

Standards and Units of Illumination.—The ancient men of the Stone Age who painted designs on the walls of their caves needed artificial light, and must occasionally have had some idea of measuring the duration and value of lighting at their disposal. It was in this respect not a very great advance from their day to the method of estimating units of light as originally proposed. Gas-light was reckoned in candle-power, the unit of illumination on this system being a spermaceti candle which burned 120 grains in the hour.

There is yet no absolute standard in the sense that length or mass can be measured by standards. For practical purposes there is a useful unit of light in the foot-candle, prevalent in English-speaking countries, and the metre-candle or lux used on the Continent. The flow of light received by 1 sq. ft. evenly illuminated by 1 foot-candle is called a lumen.

A foot-candle or lumen is equal to about 10·76 metre-candles or lux. An American measure, which is becoming common, is the "lambert"; or apparent lumens to the square centimetre.

The City of Copenhagen describes the illumination of their schools as "mi-direct, la force de la lumière étant de 5 bougies Heffner par m^2 de superficil, ce qui donne environ 25 Lux sur les surfaces de table." This is about 2·5 foot-candles on the desk, sufficient, but not too much.

Foot-candles multiplied by 0·00108 are reduced to "lamberts." The light given out by a candle varies a little with atmospheric conditions. Attempts are being made, with constantly increasing accuracy, to obtain reproducible units. One day there will be an official international candle-power, but at present this depends on comparisons with the light of certain constant electric bulbs kept in national laboratories in America, England, and Japan.

Illumination is the result of distribution of light. The amount of light falling on a surface at right angles to the direction of the rays varies inversely as the square of the distance from the source of light. If the surface is inclined so that the light becomes incident at an angle θ, then the amount of light incident on the surface varies as $\cos\theta$. The illumination of the amount of light E from a source of intensity I on any unit of surface at distance d is therefore expressed by the relation $E = \frac{I}{d^2}\cos\theta$. This is sometimes forgotten in relation to slanting desks, books, or blackboards, but is a relation which may materially affect the value of illumination in a school-room (p. 808). I is measured in candle-power, E in foot-candles.

Light Sources.—The light from a source belongs to itself, and the brightness of the source is spoken of as its intrinsic brilliancy. This is measured in candles per square inch. The candle with a flame of about 0·4 sq. in. area and candle-power 1 has an intrinsic brilliancy of 2·5 candles per square inch. A petroleum lamp of 5–15 candle-power, with flame area 1 to 3 sq. in., has an intrinsic brilliancy about five candles per square inch. By the same means the intrinsic brilliancies may be stated approximately as follows: acetylene, 10–25; incandescent low-pressure gas mantle, 10–30; carbon filament, 400; metal filament, 800; gas-filled lamps about 5000; average brightness of the sky, 3; and the sun's disc itself more than a hundred thousand times this average sky brightness.

With shaded lights the order of brightness is somewhat of the order: Opal globe around metal filament lamp, 0·1 to 0·5; silk shades, chinese lanterns, and so on, about 0·01 to 0·2.

The candle flame approximates to the brightness of the sky, and is about the most the eye can stand with comfort, so that this is taken and it is confirmed by actual experiment as the minimum

permissible intrinsic brilliancy of 2 to 3 candle-power per square inch, where the light source has to be seen by the eye.

With high-power sources, incandescent bodies and so on, the intensity of the source must be let down by translucent shades of increased area but diminished brilliancy.

Surface Brightness.—When illumination falls on a body, this is seen by the light it throws off or transmits. It becomes a secondary source of light, but in this case the light observed is estimated as surface brightness.

Whilst the illumination on a surface depends only on its position in relation to the source of light, and is measured in foot-candles, the surface brightness depends on this illumination modified by the surface itself. Illumination is the light falling on a surface, surface brightness the light coming from the surface. The surface may be of a coloured material which absorbs more light of one colour than

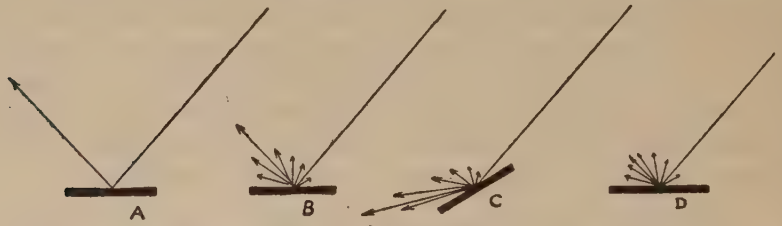


FIG. 148.—VARIETIES OF REFLECTION OF LIGHT.

A, regular; B, specular with some diffusion; C, the same surface, but increased regular reflection; D, wholly diffuse reflection.

of another. With the same illumination the surface-brightness may vary enormously. White blotting-paper, for instance, returning 82 per cent. of the light; newspaper, 50 to 70; yellow wall-paper, 40; blue paper, 25; dark brown, 13; black cloth, 1·2; black velvet, 0·4.

Fig. 148 illustrates how some of the light may be reflected in a quite regular way so that the reflected light leaves the surface at the same angle that the light was incident on it, (A); some surfaces spread the light a little, (B); and others in a diffuse way, (D).

A very white surface with almost perfect diffuse reflection for experimental purposes is best found by using finely precipitated magnesia powder. For practical purposes white cardboard or blotting-paper are nearly as useful, reflecting irregularly about 90 per cent. of the incident light. Polished silver reflects about 93 per cent., but polished gold, absorbing much colour and reflecting excess of yellow, only gives 80 per cent.

Regular reflection, or reflection which for school purposes is nearly regular, may be called specular, as it approximates to reflection from a mirror, whilst other forms are called irregular reflection.

All surfaces present these varieties in proportions depending partly on the angle at which the light is incident, and partly on the condition of the surface itself. The smoother and more compact the surface, and the more slanting the incidence of the light, the greater the proportion of specular reflection. This is seen in connection with the glare of shiny surfaces (C), the shine depending on specular reflection, and its measurement being important in considering school positions and materials.

Sky Brightness.—The first and greatest source of light is the sky. Its diffuse sunlight may be taken as normal daylight illumination. There is no standard of daylight colour or intensity. These varying

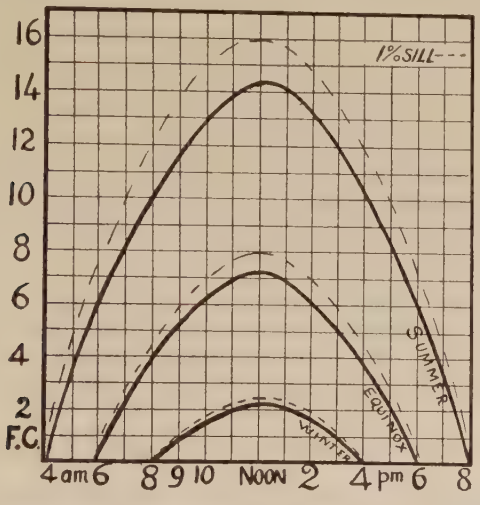


FIG. 149.—AVERAGE ILLUMINATION IN FOOT-CANDLES, AT VARIOUS HOURS AND SEASONS, OF A DESK HAVING THE MINIMUM RECOMMENDED SILL RATIO.

with the proportion of direct, diffused, reflected or refracted sunlight. The yellow sunlight differs from that through white clouds, and this again from the light of a blue firmament. As the sun appears to rise and fall in the heavens both daily and annually, the light surges unequally in tides of night and day, summer and winter. In the brightest hours of the English day it exceeds 100 candle-power per square foot. If in a rough way this be taken, the effect of skylight at any place in a room can be estimated. Discounted by 25 per cent. for windows, then the 75 candle-power per square foot, multiplied by the square feet of window through which sky is visible from a place, gives the available candle-power. This divided by the square of the distance of the place from the window gives a rough approximation to its average illumination in foot-candles.

Waldram has collated measurements of daylight at various

times and seasons, and by averaging them has presented data in a diagrammatic way to shew the expected illumination at any hour or season, on a desk which receives 0·005 of the zenith sky brightness. The diurnal variation, or rather variation from minute to minute, may be very great, so that in a building, making measurements spread over some hours, there may need to be a constant reference to the sky brightness as a datum. The black curves give the average illumination on a desk, allowing 10 per cent. off for accidents such as dusty windows, from the theoretical 1 per cent. of the sill ratio, shewn by the dotted curves.

The sky brightness is measured like any other quantity of light by the instruments described later. The illumination directly due to the sky within a room at a point on a horizontal plane depends on, first, the amount of sky visible from the point; second, the brightness of this area of sky; third, its angular elevation.

If the lighting is effected by vertical windows, the solid angle subtended by the sky visible at any working position on the plane of reference is usually small enough for the illumination there to be given by the formula $E = I\,\omega \sin\theta$, where I is the sky brightness in candles per square foot, ω is the solid angle it subtends, and θ the average angle of elevation.

This solid angle can be stated in square degrees of which there are approximately 41,250 on the surface of a sphere. The angle subtended by an arc equal to the radius is called a radian. It is about $57\frac{1}{2}$ degrees. The corresponding solid angle would be a steradian. As the area of a square degree is $\frac{\pi^2}{180^2}$ units of area, this is the value of a square degree in steradians in the sphere of unit radius. One steradian is 3282·8 square degrees.

A window 6 ft. high and 3 ft. wide at the distance of 12 ft. will give a solid angle of $\frac{6 \times 3}{12^2} = \frac{18}{144} = \frac{1}{8}$ steradian, or $\frac{3282 \cdot 8}{8}$, equal to 420·7 square degrees. At 30 ft. $\frac{6 \times 3}{30^2} = \frac{1}{50}$ steradian = 65·6 square degrees.

Hermann Cohn, in Breslau, in his examinations, noticed many school places from which no sky was visible. It is a commentary on German schools of the last generation that Cohn (1884) found 28 per cent. of the places in seventy schools had no sky to be seen. He postulated a requirement for every school place that at least 50 square degrees of sky must be visible. Gillert, in 1890, made daily measurements in a Berlin school for a whole year. He pointed out the importance of the elevation of the visible sky.

With an average elevation of 5 degrees it needed 574 square degrees to give the same illumination as 50 square degrees at 90 degrees

elevation. The actual square degrees ω, multiplied by the sine of the angle α of average elevation gives reduced square degrees, and $\omega \sin \alpha$ is a measure of the illumination, neglecting wall reflections. Cohn, in 1893, reviewed the whole subject, and now stated the minimum requirement as 50 reduced square degrees of visible sky. The principles of determining this measurement were so well illustrated by the instrument devised by Weber, the solid angle measurer, *Raumwinkelmesser*, that it is illustrated in Fig. 150.

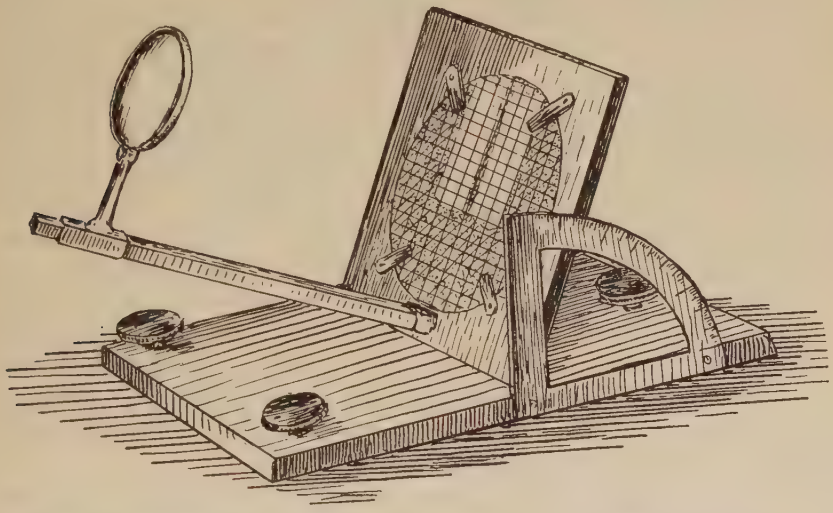


FIG. 150.—WEBER'S RAUMWINKELMESSER FOR MEASURING SOLID ANGLES OF ILLUMINATING AREA.

Sometimes it is useful to express the sky brightness I, not in candles per square foot, but in foot-candles (e), which means the brightness a dead white perfect reflecting surface would have if it received an illumination of this value—

$$\mathrm{I}\,\omega \sin\theta = \frac{e}{\pi}\omega \sin\theta$$

One advantage of expressing the sky brightness in this way is that the illumination on a horizontal surface due to a sky of indefinite extent (the "unrestricted daylight illumination") becomes equal to the brightness of the sky itself. The mathematical demonstration of this is given by Waldram (*Ill. Eng.*, January 1924). Pleier (*Zeit. f. S.*, 1909. 461, and *Ill. Eng.*, 1914. 361) has worked out a simple formula by which sometimes the reduced square degrees can be calculated for a desk. If m is the perpendicular distance of the desk from the window wall, n its horizontal distance in the plane of this wall from the point on the window corresponding to the centre of the visible sky, o the vertical height of this point above the desk,

a the average horizontal, and h the average vertical width of the portion of window corresponding to the sky visible from the desk, then

$$\omega \sin \theta = 3283 \frac{a\,h\,m\,o}{(m^2 + n^2 + o^2)^2}$$

The ratio between the unrestricted illumination out of doors and the illumination at any point in a school-room should be a constant, only depending on the building, and not on climatic conditions. Weber suggests, and Waldram separately arrived at the conclusion, that the worst lighted place should have a minimum of 0·5 per cent. of the so-called unrestricted illumination. This works out at the "sill ratio" used by the Committee of the Illuminating Society in their Journal (July 1914). The sill ratio represents half the unrestricted illumination—"daylight factor"—neglecting adjacent buildings, which for schools should be at sufficiently low angle to be negligible. The minimum brightness of the worst-lighted place should be at least 1 per cent. of the window-sill measurement outside; that is, the sill ratio is 1 : 100 as a minimum requirement.

Photometry for School Purposes.—The measurement of illumination for school purposes was so inconvenient that when Cohn began his work he took the human eye as the best measure, in its capacity to read small print at a certain distance. His test was reading comfortably diamond print at half a metre.

Weber's photometer, introduced in 1883, commenced a new era of scientific work, but for rapid work it was a slow instrument, and one of the latest school workers using it, Dr. M. Gstettner of Vienna, in 1913, complained of the rapid variations of lighting whilst using it, making her comparisons problematical.

Wingen's photometer was the first handy school instrument, and was improved by Trotter (*Ill. Eng.*, June 1910). These depended on a benzine flame and have been now discarded. The most practical and useful school photometer the writer has used is the Holophane Lumeter of Dow and MacKinney. An electric lamp run by an accumulator is enclosed in a cylinder of dead white inside. A small window in this cylinder covered with ground opal glass is thus illumined from the inside. By a specially contrived shutter any proportion of this evenly illuminated opal can be cut off. A pointer gives the proportion of light being used. A small circular surface is illuminated by the opal glass, and in this is cut a central aperture of about one-third the area, through which the surface to be tested is viewed. For measuring illumination this surface is a white matt celluloid plate placed where the illumination is to be measured. Whilst viewing this celluloid surface the shutter is moved about until balance is obtained between the brightness of the annulus with measured illumination, and the object seen

through the central aperture. This object is the small celluloid plate illuminated by the light to be tested and measured.

Where the illumination is of too intense an order it can be reduced by $\frac{1}{10}$, or $\frac{1}{100}$, or $\frac{1}{1000}$, by the use of a couple of dark glasses sliding behind the central opening. Each instrument is calibrated before being sent out. The portability of the instrument and the use of the detached matt celluloid test screen, which can be placed or supported in positions without trouble where the instrument itself would be inconvenient, make it very useful in school-work.

There are many other varieties of instruments described, but the above are found convenient.

Cohn tried the effect of light on photographic paper, and many medical officers of health have published reports of observations of this kind, but they have been found unsatisfactory. The most sensible work in this direction was that of Dr. Wilson (Linsey, Lincs.,

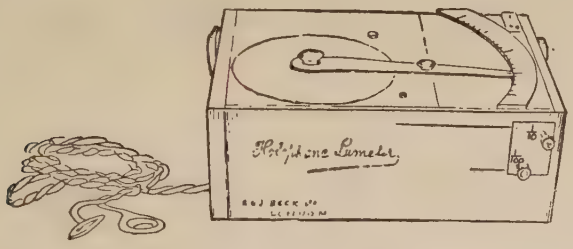


FIG. 151.—THE PORTABLE LUMETER.

1912) who simultaneously compared inside and outside values with a Watkins Bee meter. He directed exposure at 45° to horizon in rooms. One of his measurements was—

$$\frac{A}{B} = \frac{\text{Outside value}}{\text{Inside value}} = \frac{23 \text{ in.}}{210 \text{ in.}} = 0{\cdot}109$$

He concludes that if the value $\frac{A}{B}$ is equal to—

0·1 to 0·08	Illumination very good
0·08 to 0·05	Good
0·05 to 0·02	Fair
0·02 or less	Bad

This outside value should be double the sill ratio and is the daylight factor which corresponds to "unrestricted sky brightness," and the minimum value assigned to a place sufficiently lighted by Weber, Waldram, and others was 0·05 of this. Dr. Wilson's results are therefore concordant and in rough agreement, but all places with values below 0·05 should be condemned.

Actual variations of light in school-rooms are very great. A

typical instance of a school hall on a sunny May morning is illustrated. The direction of the sunlight is given by arrows, its elevation was about 50 degrees, and through the open window it just exceeded 2000 foot-candles. The measurement noted on the wall was with the test screen vertical. The other values were got immediately below the crosses marking the lighting-points, with the screen horizontal and 30 in. above the floor.

A little later on the same day a neighbouring infants' department with an old-fashioned hall, about five times as long as its width of 19 ft., gave average readings of 1·8, 1·1, 0·9, 1·2, 3·0, and 2·1

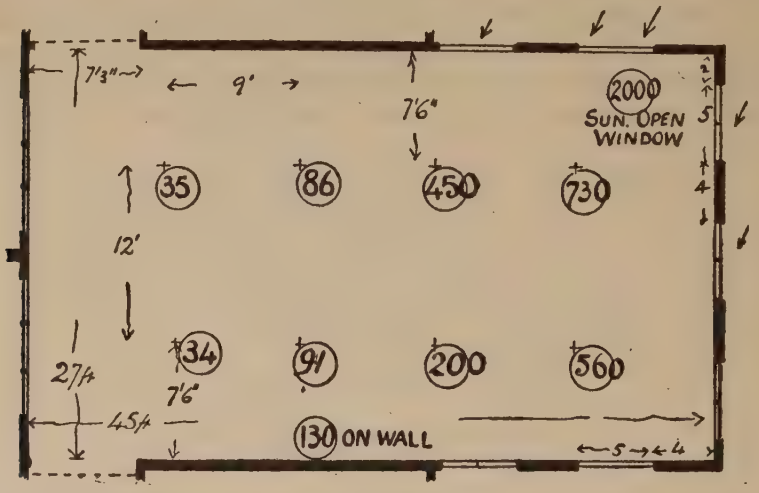


FIG. 152.—FORENOON MEASUREMENTS IN A SCHOOL HALL.

A small patch in sunshine giving 2000 foot-candles. The direction of sunshine shewn by arrows.

foot-candles, whilst the teacher's table under a skylight gave 8·0 foot-candles. These are typical of good and bad halls.

School Measurements.—The use of reading types at certain distances, and by some French authorities of dimming glasses, has been developed by Katz, of St. Petersburgh, in what he calls a *Lichtvorratsmesser*, a measurer of the light reserve. He thinks this as necessary in school as a clock or thermometer. Photometry in metre candles is not enough. Prolonged occupation has to be considered.

M_1 being the illumination just sufficient to enable the object to be distinctly seen, and M_2 the illumination necessary for continued work with the test object as determined by the frequency of blinking, over that with normal daylight as a measure of fatigue. $M_2 - M_1$ represents the reserve of light supply, and $\frac{M_2}{M_1}$ is the reserve coefficient for illumination during prolonged work, a constant of the value 25.

As $M_1 = \frac{M_2}{25}$ it follows that the reserve is $\frac{24}{25} M_2$.

The illumination, then, can only be considered sufficient if the working objects are discernable after $\frac{24}{25}$, or 96 per cent. of the brightness has been suppressed. This Katz does by the use of a smoked glass which only passes 4 per cent. of the light.

If the objects cannot be clearly seen through it, he deems the lighting insufficient for prolonged work (*Inter. Arch. f. Schul. Hyg.*, viii. 414).

Cohn, as the result of his many determinations, concluded that the minimum illumination for a place should be 10 metre-candles, but Erismann points out that this is with red light, and that for white light 25 metre-candles is the minimum corresponding to Cohn's requirements, and that to repeat the minimum as 10 metre-candles is a " very fatal misunderstanding."

Until actual measurements are made it is difficult for anyone to realize what variations in illumination may exist in different parts of the same rooms. The last two diagrams illustrate typical variations found.

All the photometric methods mentioned give absolute values in candle-power, but for school purposes relative photometry as the determination of the sill ratio is usually sufficient.

The first instrument of this kind was Thorner's Light Tester. A small metal camera with mirror and lens throws an image of the illuminating sky on a card in the bottom of the camera.

From the top of the camera this can be viewed through a slit, and a hole in the card and the bottom allows a view of a white card illuminated by the lighting of the place. By adjusting the brightness of the sky image by means of diaphragms it can be judged whether the image on the bottom of the camera or that of the test card is brightest. The stops supplied are $\frac{F}{5}$, $\frac{F}{6}$, and $\frac{F}{7}$. If $\frac{F}{6}$ has to be used to diminish the sky brightness below that of the place tested, then the place is too dark for school.

The instrument and the observer's head restrict illumination on the test card, and Professor L. Weber has modified the apparatus to avoid this, and added an iris diaphragm, thus considerably improving the instrument as a Relative Photometer (*Ill. Eng.*, 1911. 243).

Window Light.—Windows are primarily to admit light. It is only in recent years that their value in ventilation has been sufficiently appreciated, and almost in recent months that the devitalizing effect of window glass on daylight has become known.

One would naturally say that light in all directions was the valuable kind for school purposes. That light before, behind, from right and from left, as well as from above would help the eye.

Actually this is not so. The condition where, as in nature, light is well diffused is almost impossible in a school building, and violent contrasts easily set up a glare. Large areas of ground glass or white wall will in themselves irritate and fatigue. The distribution of brightness in a room has to be carefully managed for continuous eye-work.

Top or roof light one would suppose of great value, but here there is a difficulty, not only in rainy weather or in snow, but also in sunshine. It varies with good roof lighting from 2 to 10 per cent. of the skylight. Saw-toothed roofs have been tried in America, but they required whitewashing in summer and much care in winter, and a second roof of flat panels of diffusing glass beneath them, so

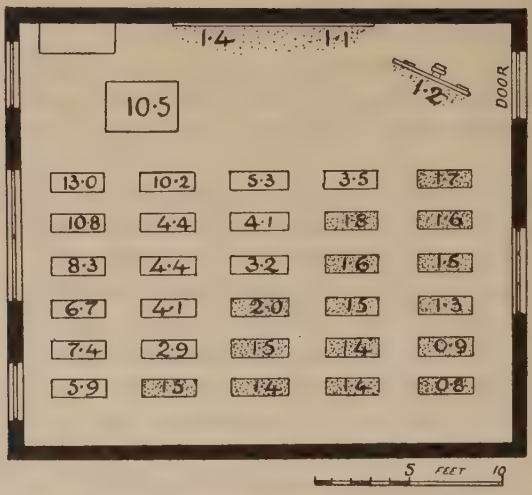


FIG. 153.—DISTRIBUTION OF ILLUMINATION IN A LOWER FLOOR ROOM.

The blackboards and parts stippled are too dark for work.

that they will never be generalized. They could only be used for single-storied buildings. In England, roof lighting is not acceptable to the Board of Education.

Although the eye almost always looks down in working, and has the illumination from above, as actual skylight or roof lighting is not a practical proposition, it must be approximated to as far as possible by high windows.

The usual form of class-room, an oblong, with one of the long walls as the window wall, is being recognized as the best for schools. For the lighting of a room, so that no part receives less than the minimum of fifty reduced square degrees of sky image, the window area must be considerable. The whole wall might be window area without harm, but that is scarcely necessary. The lower edge

of the window should not be higher than the working plane of the desk-tops. For working rules take this height of window as coming to within 3 ft. of the floor.

In old schools, built with windows so that the children could not look out, or outsiders look in, or for other reasons, the lower edge of the window is sometimes as high as 5 ft., so that the file of desks adjacent are all in shadow. The top of the window should reach close to the ceiling, within 3 in.

The size of a window has to be high and wide for lighting purposes. In winter windows are great coolers, and therefore are wanted not too large. For ventilatory purposes about 12 ft. is the useful limit of height in a room, and every inch above this means wasted money in cost of construction.

The illumination on the desks is more effective from the upper part of the windows. Each space element of window represents more reduced square degrees the higher it is. Another consideration is that the nearer the illumination on the desk-tops approaches the vertical, according to the cosine law, the brighter it is. This effect of greater efficiency of each element of window the higher it is affects the whole structure of the school building. In a single-story building the higher the roof, or rather the window-tops, the better lighted it is. With several stories it is an advantage to have the cellars not too deep, as then the class-rooms above are raised higher, above surrounding obstructions. The height of each story should not exceed the 12 ft. window height. Desks should not be on platforms, which relatively diminish the height of the room and effective illumination. For the same reason, raising the height of the children by foot-rests, which may amount to several inches, as in some Rettigbank forms, diminishes the effective height of the room by this amount. From reasons of economy, the height of the window in the class-room is therefore limited to about the 12 ft. The effective window area must not be diminished by overhanging lintels, projecting posts or pillars, or anything visible from inside the room.

The window wall can be fully utilized, beginning near the back, and leaving 3 or 4 ft. without window towards the front wall, so that there may not be hard shadows there. The spaces between the windows should be strong enough for architectural purposes, but not wide enough to cast shadows over the room.

The windows of the school-room are usually unobjectionable in modern schools, but when the lower edge is too high so that there is dark wall beneath, it is possible for the contrast of dark wall and bright window to be unpleasant if not glaring. With a deep room this result may be troublesome, more marked with darkly coloured walls, and especially with small windows. Where ribbed glass comes in, or, more rarely, diffusing glass with perhaps a pattern

cut in it, the contrast between the bright spots and dark surroundings makes the window a source of annoyance in sunlight, especially if it has a south-east or south-west exposure.

Two diagrams are given as worked out by Dr. A. C. Williams, shewing typical London class-rooms and their daylight illumination. The first, Fig. 153, taken in a ground-floor room, gives the surface brightness on each dual desk taken in the writing position with a slope about 10 degrees. The second, Fig. 154, gives measurements for the corresponding room two floors above. Here the values were taken in the reading position of the desks sloped at 30 degrees. The effect of the height of the story is shewn by the measurements on the blackboards. The borrowed light, too, on the left hand is of no effect.

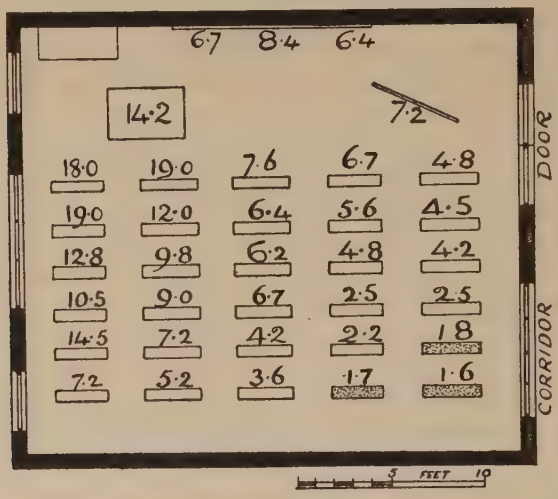


FIG. 154.—CLASS-ROOM ON HIGHER FLOOR.
Stippled where too dark.

Various rough rules have been proposed as regards minimum window area in proportion to floor space. Glass area equal to one-fifth the floor surface is the value stated for England. On the other hand, in the Transvaal, this is excessive, and in Northern Europe it is insufficient, a quarter being asked for. Obviously, the desirable ratio is a matter of latitude, varying from a quarter to a sixth.

Englebracht, a German architect, worked out a formula for Germany which, expressed in English measures, is $f = \frac{F}{5} \times \frac{x^2}{387}$, where f is a window area, F floor area, and x width of room, all expressed in feet. It suits the latitude of England well.

Light from the Sky.—Javal, the French ophthalmologist, first

insisted on a visible sky as a necessity for window lighting. He suggested that a strip at least 12 in. from the top of the window was needed ; and this was adopted in 1882 by the French Government. A strip of 30 cm. sky being required to be visible from every place.

A little later Foerster (1884) proposed what he called an " Offnungswinkel," an angle of vertical opening of at least 4 degrees in the two lines drawn from the working place at the top of the window, and to the top of the nearest buildings. He made the proviso that the top of the window must have an angular elevation of at least 27 degrees. His suggestions have a bearing on the width

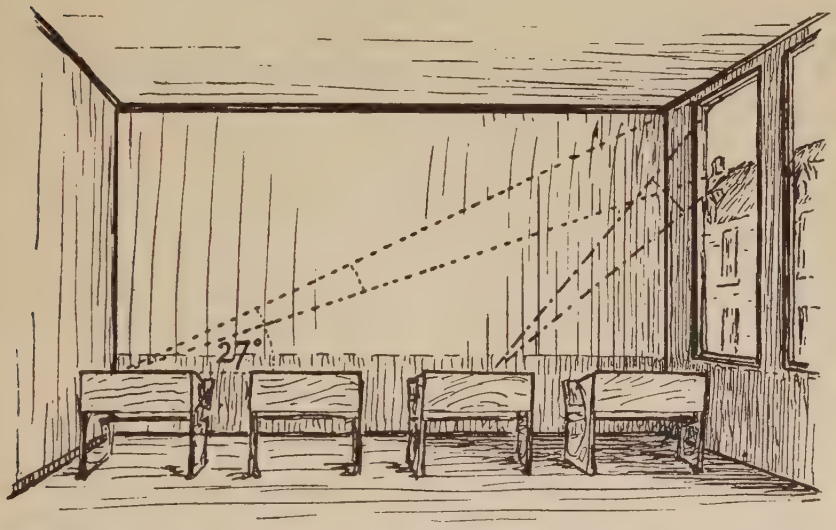


FIG. 155.—ANGULAR OPENING AND ELEVATION OF EFFECTIVE SKY AREA.

of the room, for if H is the vertical height of the top of the window above the desk-top, the maximum distance x of any desk to carry out this requirement would be $x = \text{H cotan } 27° = \text{H} \times 1{\cdot}96$, or the width of the room should not exceed twice the vertical height of the top of the window above the desk-level.

These suggestions do not make any provision for width of windows. The measurements of solid angle of sky with Weber's solid angle measurer (Fig. 150), which Cohn used, was a distinct advance (Fig. 800). When the measurements were further improved by Gillert's correction (1890) for elevation, so that reduced solid angles were used, a definite value for daylight was reached in 50 reduced solid degrees. It is obvious that this 50 reduced square degrees is an empirical measure which will vary with latitude, and an additional correction could be introduced in this regard. The

top of a window, then, is of greater illuminating quality than the lower segments.

Pleier, in Karlsbad, invented an ingenious pinhole camera for measuring the reduced square degrees at once by a photograph. The writer, by making a negative of a wall chart on which reduced square degrees obtained by calculation had been drawn, obtained a means of measuring accurately by always using the same fixed-lens camera, the window or any other vertical area from any place, in reduced square degrees.

This work is useful to the architect about to design a building, as it gives him control beforehand of the possibilities of lighting. It is not of any great value, however, in actual school-work. In existing schools, like the CO_2 index in ventilation, the sky area is not now of prime importance for exact measurement. The lighting of a school place does not depend entirely on direct light from the window. There may be no sky visible from a place, but yet sufficient light from reflections from walls, ceiling, and furniture. This is a possibility, not a probability.

Pleier used the brightness of the sky as his datum and assumed the whole firmament as of equal brightness. He states that for daylight " the condition of illumination of any place in a building to any other place is a constant ratio," and that the daylight of all places rises and falls proportionately to the light of the sky. He thus introduces a light quotient (*Beleuchtungsquotient*)—

$$\frac{\text{Illumination at place}}{\text{Illumination of sky}} = \frac{a}{A} = Q$$

This depends on ρ, the reduced square degrees of sky visible from the place (p. 801), there being 10,310 square degrees in the hemisphere, and on the element of reflection from walls and furniture. This lighting quotient is practically another expression of the daylight factor already referred to, and recently exhaustively examined by Waldram (*Ill. Eng.*, 1923. 89). It should be unaffected by absolute variations in daylight, though it is based on an assumed uniformly white sky. It depends on the area of unobstructed sky visible, the position and dimensions of windows, and the nature and decoration of the walls, ceiling, and furniture of the room.

In Pleier's papers (*Zeit. f. S.*, 1909. 227, and 1911. 197) he has shewn that with distance from the window the illumination diminishes less than the square angles visible. This had already been shewn by Erismann (*Zeit. f. S.*, 1894. 90). Pleier shewed, too, that the further from the window the more important became the reflections. He worked out experimentally, and by calculation, each element of 250 sq. cm. of the room walls, and proved the relation of each reflex to be a constant depending on the sky intensity, and that the light quotient for each place remained constant. The

history of experimental enquiry following Cohn's pioneer research of 1883 shews how numerous workers have gradually simplified it, and crept nearer solutions. It is of interest to anyone planning out investigations, and is given briefly in the *Ill. Eng.*, January 1914. 27.

Window lighting is generally held to be best when it comes entirely from the left. The window should be practically the whole surface of the wall, from 3 ft. above the floor on the pupils' left hand. Some French writers have put in a plea for right-hand lighting as well, but have the proviso that it should be less powerful than the left-hand light, or else that the right-hand windows should be translucent and diffusing to prevent sharp shadows.

In a return made of 466 schools under the School Board for London (1902), 7813 class-rooms had side lighting, and 1365 back lighting. Since then the conditions have been enormously improved, and back lighting may now be left out of account; although it persists here and there, strict regulations should be drawn up requiring its abolition within a reasonable time, say five years. One need hardly discuss these windows *en face*, or behind the pupils, which the neglect of the Board of Education still permits in England, as the condition of the class-room means that facing windows are severely glaring for either teachers or children. In the case of teachers this seems to be an occasional cause of sleeplessness and ultimate neurasthenia, even when headaches do not occur. Where there is a migrainous tendency, which is not rare among the teachers under 40, headaches may be frequent and severe, and attributed to the glare.

In one condition, which the writer has not seen actually tried, the back wall might have a small window high up and remote from the main window wall, but the window should have its purpose ventilation, and be hinged below to open inwards, and glazed so that all the entering light is reflected to the ceiling over the centre and front of the room. The diffused light would then be exceedingly useful without being in any way glaring.

Shadow on the writing point is the great reason for illumination from the left side, and multiple shadows become confusing.

With the light behind, the child sits in its own shadow, with its work getting perhaps a twentieth of the light available if properly directed. Another reason for light from the left is that with right-handed pupils light from the front and more still from the right would produce the maximum glaring effect from paper, desk, and window. In bright light a certain amount of glare occurs even with left lighting if the pupil sits at work in a twisted position, and one style of desk has been introduced with a view of avoiding this glare in the strongly lighted rooms of California.

The writer has seen whole classes of girls in London sitting turned

round on their desks, with their feet on the seats, as otherwise, owing to bad lighting, needle-work was difficult.

In the Derbyshire schools, when experimental rooms were used with sloped studio windows to get high-angle lighting from the left, a clerestory of smaller lights was introduced on the right, partly for ventilation and partly to satisfy the popular idea that sunlight in a class-room was useful. These lights had to be provided with curtains, and would have been better omitted from the point of view of illumination.

Sunshine.—The English Building Regulations state : " 19a. The need for really effective ventilation and the importance of securing abundant sunlight are now generally recognized." This is one of the vague flourishes for which it would be difficult to find reasons. The same Regulations, " 137. Windows which face the sun should have blinds," is a more practical statement.

Sunlight is recognized as not wanted in class-rooms whilst the children are there. It has no therapeutic effects when passed through window glass. It is of no use when the children are out. The germs it is supposed to destroy are not so abundant that it is needed, and they are mainly protected from it by shadows. Except warmth, no real reason for " securing abundant sunlight " can be adduced that is valid for class-rooms, in which, indeed, for sound ophthalmic hygiene, it must be avoided.

All the reputable writers on School Hygiene, both Continental and American, are in agreement with this opinion set forth years ago. The cry for sunlight in the class-room is merely a popular fetich. It has no hygienic value commensurate with the nuisance which it is, and the cost required to provide effective means for its exclusion. Sunshine in the playground is an entirely different story, and a powerful reason why class-room hours should be curtailed for out-doors in sunny weather.

Measurements of surface brightness have shewn that borrowed lights are of little use so far as class-rooms are concerned. Indeed, they are usually a loss in that light which would undergo reflection instead passes out of the room. So, too, glass panels in or above doors, are wasted so far as class-rooms are concerned. Their use may be to light an otherwise dark corridor which should not exist in a well-constructed school.

Blackboards can be a cause of loss of light. American schools favour a band of black surface all round the room. It is an advantage educationally where there is sufficient room for movement and proper teaching, but impossible to use for want of space in English schools. The amount of absorption of light is serious, and when not in use light covers should be able to be pulled down over the black surfaces facing windows. Basquin and Scott found 50 per cent. increase in the illumination of the darkest places in American schools

when the covers were over the blackboards (*School House*, U.S.A., 1910, No. 5. 76.)

Surfaces of ground glass, over white settings, would allow free use of coloured chalks and do not absorb light. Cost is probably the chief hindrance to their use.

The light-reflecting values of different coloured surfaces depend partly on the colour of the incident light and partly on the texture of the surface. H. A. Gardner (*Ill. Eng.*, 1916. 226) tried to obtain comparative values for colours by painting discs with different colours, and testing them. Using as the standard of reflection Magnesium Carbonate 88 per cent. the following values were obtained for coefficients of percentage reflection—

Light cream	66	Light terra-cotta ..	41
Light pink	60	Medium terra-cotta ..	39
Light yellow	58	Medium blue	32
Light blue	55	Warm green	19
Greens to yellow ..	54	Medium green	14
Light buff	52	Red—dark blue ..	12
Light green	42	Green	11

School walls should be optically matt, not glaringly smooth, and according to the above table for good reflective qualities, should be one of the first three colours—light cream, pink, or yellow.

Improving the illumination by attention to walls and ceiling may not very materially increase the actual illumination on the work, but it aids diffusion, reduces shadow and glare, and increases the general feeling of light and warmth. Its psychical result, indeed, may be greater than the physical effect. For this reason the reflection factor of the upper part of the room should be high, the ceiling 65 per cent., the walls 30 to 50 per cent., whilst the lower part of the room and furniture should not exceed 25 per cent.

The Boston School Commission (*School Document*, No. 14, 1907) give a plate of sample colours as used. Chrome green with white reflecting 46 per cent. of incident light, or chrome yellow, white, and lemon reflecting 51·4 per cent. were the most favoured. They found most of the colours in actual use too dark. After two years' work, a Joint Committee of the Illuminating Engineering Society reported on Daylight Illumination of Schools in 1913. The full report is published (*Ill. Eng.*, July 1913). It may be summarized in the words of the Committee : " No place is fit for use in a school-room when diamond type cannot be read easily by a normal observer at a distance of half a metre (20 in.)."

This is diamond type.

The darkest desk in any school-room needs to receive an illumination equivalent to that derived directly from 50 reduced

square degrees of visible sky. In these circumstances, the place probably receives not less than 0·5 per cent. of the unrestricted illumination from the complete sky hemisphere.

The windows ought to be located in the wall to the left of the pupils, and the glass carried to the ceiling and not interrupted by cornices, pillars, or decorations.

No desk in a school-room farther from the window wall than twice the height of the top of the glass above the desk surface is likely to get sufficient light.

The ceiling is best if white. The wall opposite the window and the wall behind the children being lightly coloured from 30 in. above the desk-level. The wall around or behind blackboards is better if somewhat darker than the rest of the room.

If colouring is used, the yellow tints are superior for artificial lighting with the usual lamps. Blue or dove-coloured greys reduce the light, although they would be useful, on the other hand, with " daylight " lamps, which are too costly for school use.

All furniture, desks, and surfaces in the lower part of the room have possibilities of glare reduced if they are finished in an unobtrusive colour, dark shades and black being avoided.

The English Board of Education Regulations, 1914, for the lighting of class-rooms in elementary or secondary schools are summed here for reference.

50. *Lighting of Class-rooms.*—The area of window-glass should be approximately one-fifth of the area of the floor space.

51. The windows should be so distributed as to light every table or desk, and the whole of the room evenly and sufficiently. The last vertical glass-line of the window furthest from the teacher should be on a line with the last row of desks.

52. (*a*) Where windows are provided in one wall only, this must be the wall on the left of the scholars as seated. (*b*) Any additional windows should be placed in the right-hand wall, but not so as to throw a stronger light from the right of the scholars than from the left. (*c*) Windows facing either scholars or the teacher are to be avoided. (*d*) Skylights cannot be approved in " main rooms " or class-rooms except in special circumstances.

53. Unless the top of the window be more than 12 ft. above the floor, no desk should be more than 20 ft. from a window.

54. (*a*) The lower glass-line of the main lighting windows should not be more than 3 ft. 6 in. above the floor. (*b*) The tops of the windows should, as a rule, reach nearly to the ceiling.

55. French casements may be approved for some rooms.

56. Windows should never be provided for the sake merely of external effect. Clear glass should be used in the windows, and all kinds of glazing which diminish the light and are troublesome to keep clean and in repair must be avoided.

57. The upper panels of the doors may be glazed with clear glass, in order to facilitate supervision without disturbance to the work in the room.

58. The colours of the walls and of the ceilings and of all fittings in the rooms should be carefully considered as affecting the light.

It will be noticed that no minimum illumination for a place is defined, nor have the Regulations reference to any requirements or standards of artificial lighting. These are matters in which minimal requirements should be prescribed.

Natural or day lighting is of an extraordinary variable character, and almost beyond control save for the securing of minima below which a place must not fall. Fortunately, in all other respects nature has evolved a controlling mechanism in the adaptation of the eye. The minimum accepted for the darkest working-place in school is 2 foot-candles, although this in reality should be 5 foot-candles if daylight is to be comfortable for continuous work.

Three to 5 foot-candles is justified by the experiments of Ferree, Clarke, and others, which shew that visual acuity increases with candle-power rapidly to 3, and more slowly to 5, after which the increase is slow. Rapidity of reading as expressed by the reciprocal of the time to recognize a letter increases rapidly to 4 candle-power, and more slowly to 12. A recent investigation shews that ordinary shop lighting on the counters lies between 5 and 10 foot-candles, and that there is no appreciable gain beyond 10 foot-candles. The American standard of minimum, 5 foot-candles, for class-room desk surface is justified for daylight, and probably also worth the cost for artificial lighting.

The code of the American Illuminating Engineering Society suggests that the minimum daylight provision should be three times that of the minimum intensities provided by artificial light, for which they suggest 3 foot-candles.

With artificial light the whole course of events is completely within control. The problems are as to when artificial light is necessary, what amount should be provided, and how it is to be distributed.

These words are written on paper within 22 in. from a hundred-watt daylight, gas-filled tungsten bulb, a stronger light than any school provision, which yet helps the eye to work continuously with a sense of relief and comfort.

The eye, with its enormous adjustability by adaptation, must be the judge of the "gloamin'" becoming too dark. The proposition has been made to use selenium cells as feeble illumination meters, but no apparatus approximates to the sensitiveness of the eye in this respect. If an instrument is required to ascertain a definite limit, then the Katz light-tester would be sufficient. It is too dark for work when objects cannot be seen clearly through an obscuring glass with 4 per cent. transmissibility.

Gas or Electricity.—Local economic circumstances may have to determine whether incandescent gas mantles or electric bulbs are used. Both have been cheapened and increased in efficiency in recent years. Electricity has many advantages in its flexibility

in use. The ease of distribution in many points is great. Heat production is low, and there are no by-products in the atmosphere. It requires little attention in use, and efficiency does not deteriorate rapidly. Gas in the form of the batswing burner, with its by-products, is obsolete. Incandescent burners have attained great perfection with the inverted mantles, but they heat the atmosphere, and the products of combustion are not quite negligible. Much attention and intelligent care is necessary or the deterioration is rapid. The hot convection currents deposit dust on cooler surfaces so that ceilings soon become discoloured when gas illumination is used.

A comprehensive and most informative paper on the comparison of the two kinds of lighting, with many kindred problems, was published by Dr. S. Rideal in the *Journ. Roy. San. Inst.*, March 1908. He found human contributions to atmospheric impurity greater than any due to light sources, and that the heating effect did not differ significantly with gas or electricity. The bacterial content was less with gas, put down by Rideal to cremation of germs, and physiological differences were scarcely noticeable. Experience since then shews that for cleanliness and convenience, upkeep, and in some degree the physical condition of the atmosphere, electricity, where available, has advantages, but that the disadvantages of gas in modern forms are not great. Whilst hygienic reasons would always give electricity the preference, it is probable that economic considerations will determine any particular case.

Intrinsic Brilliance of Sources.—The sources of artificial light for school use are incandescent flames, textures, or wires. The electric arc used occasionally in art rooms, or for other very special purposes, is here left out of consideration. Candles, oil, or gas flames were all of low intensity compared with modern illuminants. The intrinsic brilliancy of any source can be estimated in candles per square inch, and as stated, in discussing glare, the eye cannot persistently tolerate a source of brightness greater than about 3 candles per square inch, which is the order of average sky brightness. The filament of a tungsten lamp has an intrinsic brightness about 1000 candles per square inch, and for gas-filled lamps this reaches about 4000 or 5000 candles. The ordinary gas mantle is less than a hundredth of this, 30 candles per square inch. For hygienic use this high potential light must be let down. The transformers used are shades or reflectors, and no source of light exceeding 3 candles per square inch should be continuously exposed to the eye. A hundred-watt vacuum tungsten lamp, with intrinsic brilliancy of several thousands of candles, placed at the centre of a 16-in. glass opal sphere, becomes a large, agreeable source, with a brilliancy of about 2·0 to 3·0 candles per square inch (p. 797). The Admiralty have fixed 2·5 candles as the limit of visible surface brightness for ships fittings.

According to the methods of letting down the brilliancy, systems of lighting may be classified as direct, indirect, or semi-indirect. Although every system really involves all in varying proportion.

Direct Lighting.—Direct lighting is where all the rays of light reach the working-plane in straight lines, directly from the original source of light without reflection or refraction, by passage through translucent materials.

For local lighting of a small area it is the most effective and cheapest, though possibly in respect to the eye not the most economical way to use light. Where details of textures and fine structure have to be made out, it casts definite shadows ; on the other hand, these may interfere with work, as, for instance, in the use of a ruler and set-squares. It is concentrated over a small area, and, if shaded from the eyes so that they remain light sensitive (adapted), aids the vision in fine detail. Its distribution is irregular, and, except for the illumination of blackboards, it is inadvisable for school use.

Indirect Lighting.—Indirect lighting is that in which all the light reaches the working-plane after reflection from walls or ceiling. Shadows are thus smoothed out so that there is no sharpness about them. This is done by placing under the lamp or source of light an opaque bowl reflector, which conceals the source from the eye, and reflects the light falling within it back to the walls or ceiling. For many places where even lighting is wanted, as lecture halls, restaurants, or kinemas, this concealed lighting may provide a luxurious restfulness. Brilliancy, however, is wanting. There is a monotony and flatness which in time gives a depressing effect. Detail is lost. In an address at the Gas Conference in October 1913, the late Lord Rayleigh pointed out how, apart from colour, with even illumination in all directions objects would tend to become invisible. Contrasts and shadows are wanted for their psychological effect. The indirect lighting may have an unirritating effect, but, as a matter of economics, with the same amount of light evenly distributed over a wide area objects are not so brightly seen as they would be with the same light applied locally. A secondary result, too, is that with the general diffusion of light the eye is more light adapted, it is not nearly so sensitive, and the illumination is judged as much weaker than it really is if measured by a photometer. A greater expenditure of light is required to get the same subjective effect as with direct lighting. For reading or writing, or working with varying colours, it is pleasant, but its shadowless quality makes it troublesome and fatiguing to distinguish fine objects or uneven textures. Bishop Harman relates how for this reason the indirect lighting provided in the new dissecting rooms at Cambridge had to be immediately replaced by direct illumination.

Semi-indirect.—A combination where a great part of the lighting is by indirect means, whilst the rest is transmitted through diffusing

shades is known as half-indirect, or semi-indirect. If the coefficient of transmissibility of the shade is high the lighting approaches a mitigated direct lighting ; if the shade is so dense that transmissibility is low then it is nearer to indirect in its quality. Where the shade has a surface brightness not much exceeding the ceiling above, an evenly distributed illumination results without dense shadows, but still with sufficient to aid visibility. The shades should be very translucent to be economical in light, but diffusive enough to prevent the filament or mantle being seen. The walls and ceiling above the level of the lamps have to be white to obtain the greatest reflection and least absorption. The surface brightness of any visible source of light, whether opal globes or translucent shades, should not exceed

Table 103.

Nature of Lighting.	Details Visible.	Candles per Square Inch.
Indirect	Ceiling above source ..	0·01 to 0·15
Semi-indirect ..	Heavy density glassware	0·07 to 0·20
	Light density glassware	0·40 to 2·00
Direct	Ten-inch opal globe with 100-watt tungsten lamp	0·50 to 1·00
	Vacuum tungsten, frosted, in open bottom reflector	4·00 to 6·00
Filament of vacuum tungsten lamp		1000
Filament of gas-filled lamp		4000
Bare gas mantle		30·0
Gas mantle in six-inch opal globe		2·0
Clear blue skylight about		2·0

the three candles per square inch. The greatly increased brilliancy of light sources makes them dangerous to at least 10 per cent. of the children, who are commencing with myopia, unless this brilliancy is let down by shades or globes. For most school-work this is the best system.

In Cleveland, U.S.A., although a semi-direct system was deemed preferable, yet owing to the use of soft coal the direct method had to be adopted. The deterioration from polluted atmosphere and the cost of cleaning being too great to maintain efficiency (Dates, *Amer. Trans. Ill. Eng.*, November 1922. 642).

Wholly enclosed units were the most successful. Legislative action has not yet paid sufficient regard to visual hygiene; it has chiefly been aimed at protection against accidents in mills or factories. The whole subject requires overhauling from this standpoint. The Home Office Report on Workshop Lighting (Cd. 1418) calls "low brightness" that not exceeding five candles per square inch. My

own experience, and the judgment of the Joint Committee on School Lighting quoted below, was that no stronger source of light than three candles per square inch should be visible in school. A large area of light source of low brilliancy is the ideal approximation to the natural lighting of the sky. It is the principal method available for reduction of glare from artificial illumination.

The brightness of various sources of light may be tabulated as given in approximate candles per square inch (Table 103).

Bertelsmann, in Germany, found that with equal gas consumption indirect lighting gives about half the illumination obtainable with direct (*Ill. Eng.*, September 1917. 235). Croydon experiments by Sandemann (*Ill. Eng.*, January 1922) worked out the consumption with equal direct, semi-direct, and indirect as proportionate to 1, $1\frac{1}{2}$, and 2. In spite of Cleveland experience the cost of lighting is so small compared with other charges that the disadvantages of direct lighting in respect of glare should exclude it from schools. Further, the minimum laid down should only be taken as a danger-line, and a reserve lighting attained which represents two to three times this amount should always be aimed at.

The Amount of Illumination Required.—Although there may be great variation in individuals for continuous work in direct artificial light, the reading of small print is impossible with illumination of 0·1 foot-candle ; it can just be managed with 0·2 foot-candle, but is comparatively easy with 1·5 to 4·0 foot-candles. Over 6·0 foot-candles there may be a sense of effort, unless the colour is somewhat modified, and above 8·0 glare begins to be felt. With diffused daylight the eye adapts itself so that little difference is shewn between 5·0 and 500·0 foot-candles. When the minimum permissible has been defined there is always a danger of this becoming a maximum.

Three recent Codes have been published in America in close agreement as to minima, but differing as much as 30 per cent. in regard to ordinary practice. The Code of the American Illuminating Engineering Society in 1916 was followed by Industrial Regulations in Pennsylvania in 1916, and in Wisconsin in 1918. Their minima are given, and also averages for ordinary practice. In this last the upper ranges are preferable.

In a Report of the Illuminating Engineering Society Committee in 1912 on Artificial Lighting of Schools, the work was considered to fall into three divisions : (*a*) ordinary clerical work, such as reading and writing, where the minimum standard should not fall below 2, or, as many of the Committee wished, 2·5 foot-candles ; (*b*) for special work as drawing, stitching, or in workshops, a minimum of 4 foot-candles ; (*c*) for assembly rooms a general illumination of 1 foot-candle on a horizontal plane 39 in. from the floor. These are not working standards but minima. The writer, a dozen years later,

has no hesitation in saying that no scholar should be allowed to work continuously in a place with less than 3 foot-candle illumination. This is the minimum amount recommended in the Code of 1918 by the American Society, and since then the American Standard Code of Lighting (1924) has definitely adopted 5 foot-candles as the school desk minimum. The amount to work to should be at least 50 per cent. greater than any minima prescribed.

The frequency with which the I.E. Committee found bare filaments or mantles within the field of vision of children looking towards the blackboards led them to state—

"The Committee recommend that no lamps should come within the solid angle subtended at the eye by the blackboard and a space

TABLE 104.

Illumination for—	Minima.			Ordinary Practice Averaged.
	Amer. I.E.S.	Pennsylvania.	Wisconsin.	
Roadways, yards	—	0·05	0·02	0·05– 1·0
Stairs, passages	0·5	0·25	0·25	0·25– 2·5
Rough shop work	1·25	1·25	1·25	1·25– 4·0
Fine manufacturing	3·5	3·5	3·0	3·5 – 8·0
Office, typewriting	—	—	3·0	4·0 – 8·0
Class-rooms, laboratory ..	3·0	—	5·0	3·5 – 6·0
Fine work (sewing, drafting, engraving)	5·0	5·0	5·0	6·0 –15·0

2 ft. above it, unless they are completely screened from the eye by a shade impervious to light."

The writer's experience (*L.C.C. Report M.O. Educ.*, 1911) is that whilst the lighting of the separate places affects the individual scholar, the illumination of the blackboard affects the whole class, and, as a rule, it is very poor. The contrast between the blackboard and the chalk requires to be good. For education the object on which the child concentrates its attention must have brilliant and clear definition not only in the psychological, but also in the physical sense. The colours and contrasts of chalks have to be considered, especially by artificial light. Some colours are almost invisible at a short distance, and this is one of the objections to the Dale system of teaching reading. Measurements of the surface brightness of the best desks, and of the movable blackboards in a number of class-rooms, shewed the blackboard to have on an average only one-fifth of the illumination on the desks. Variations ran between one-third and one-twelfth. Since then the Committee on school lighting have recommended that the illumination on the blackboard should be 60 per cent. higher than in the rest of the class-room.

Distribution of the Light.—Some writers are disposed to regard the distribution of the light as of great importance in the genesis of eye disturbances (Cobb, *Amer. Acad. of Med.*, XV. No. 5, October 1913). C. E. Ferree (*Buff. Cong.*, 1913, V. 351) found the colour of the light a factor. The carbon lamp with more yellow and red causes the eye to fall off in efficiency faster than a tungsten lamp of equal power, and with sensitive eyes one of the so-called daylight bulbs will be found very comfortable for continuous desk work, although their cost to run preclude any general use in schools. With equal illuminations Ferree found the best order of lighting for continuous

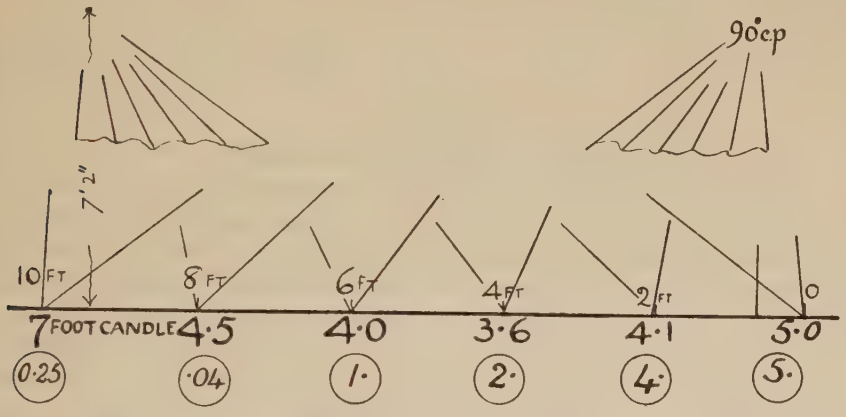


FIG. 156.—RECORDS OF ARTIFICIAL LIGHTING, IN SAME HALL AS FIG. 152.

Those in circles are with only right source used, the other with both lamps. That marked ·04 should read 0·4.

work to be daylight, indirect, semi-indirect, direct (*Trans. Amer. I.E. Soc.*, April 1919. 107).

As an example of typical gas-lighting the hall where the daylight measurements were recorded on page 804 was taken. This hall was illuminated by eight No. 3 Metro inverted burners. They were 9 ft. from the floor, of 90 candle-power each, and provided with 18-in. parabolic reflectors, symmetrically placed at 9 ft. intervals in two rows $12\frac{1}{4}$ ft. apart. The 20 × 21 class-room had four such points symmetrically, in a square of $7\frac{1}{2}$ ft. side and 8 ft. above the floor.

The surface brightness obtained on a level working plane 22 in. from the floor with both points lighted is as shewn on the diagram. With only the right-hand side lighted it is as in circles.

Experience shews that with units spaced at a distance apart greater than twice their height from the working-plane, it is impracticable with direct lighting to obtain reasonably uniform illumination. The ratio of brightest and darkest desk surface should not be greater than four. For medium power units 8 to 10 ft. above the floor is the

usual height. The importance of contrast being too great, or bright working spots in comparative darkness, and sharp contrasts of light and shade, in causing fatigue has been dealt with in regard to industrial lighting, but it plays a part in school in connection with glare.

The concentration of artificial illumination into comparatively small sources makes the angle of slope the cause of much difference between reading and writing surfaces less regular than by daylight.

In a particular case the following readings were obtained with desks sloped for writing, then turned up for reading, as in the Bennett models, each pair of readings in foot-candles being on the same desk under artificial light—

Sloped for writing..	5·1	5·5	7·2	6·8	6·4	4·8	4·0	4·9	5·6	5·4	5·1	4·5
Inverted for reading	5·7	5·7	6·6	6·4	5·0	2·7	4·4	4·5	5·0	4·8	3·8	2·6

The same small sources make shadows variable.

Formerly class-rooms were lighted by batswing flames at the end of T-shaped fittings. In some of the first observations made by Harman, he shewed how with the same gas consumption in an infant class-room, the lighting could at once be tripled by using ordinary Welsbach mantles, and again improved by suitable reflecting shades to soften the shadows of the fittings. Now with inverted mantles still greater improvement has followed, but it is advisable that they should only be used for semi-indirect illumination. In place of the four points general in class-rooms, he suggested six points over the first, fifth, and eighth place from the window in a row of ten seats, with an additional point with swivel reflector to illumine either blackboard or teacher's desk, but protect the pupils from the lamp. The London schools, which have many rooms about 20 ft. square, use in them four symmetrically placed 50 candle-power lamps, giving a minimum of 2 foot-candles per place. The best distribution of points would, however, be in six points throwing the main volume of light from the left on most of the children, as Harman suggests.

In the larger American rooms, about 28 × 24 ft., the Boston Committee (*School Doc.*, No. 14, 1907) worked out a nine-point arrangement. Such a school-room generally has seven rows of seats in six files. The lighting-points are arranged a little in front of the first, third, and fifth desk in the front, third, and sixth rows of desks, or about 2 ft. 5 in., 9 ft. 2 in., and 15 ft. 11 in. from the window wall, in a room of 24 ft. 2 in. width, and 6 ft. 13 ft., and 20 ft. from the front wall in 28 ft. length. Dates, in Cleveland, with smoky coal, uses six 150-watt Mazda lamps in enclosed opal globes, for each standard class-room. The maximum intrinsic brilliancy is 3·5 candles per inch. A 100-watt lamp in a 12-in. spherical opal gives about 3·5 to 4 candles, and a 150-watt lamp in a 15-in. opal globe would give 4 to 5 candles per square inch.

The standard class-room to which English Elementary schools should work would be for 35 children. On the 15 sq. ft. basis, this means a room 19 ft. wide and 28 ft. long. It need not be more than 12 ft. high. It would be most advantageously lighted for the pupils by six points, 7 ft. above the desk-level, placed at $4\frac{1}{2}$ ft. and $12\frac{1}{2}$ ft. from the window wall, and 8, 14, and 20 ft. from the teacher's wall. An additional swivelled reflector light to light the blackboard and the table as required should also be added. It would be 5 or 6 ft. from the wall, and about 10 or 11 ft. from the window.

CHAPTER XLIII

STATISTICS

When you can measure what you are speaking about, and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind.—Lord Kelvin.

Statistical Methods.—When large numbers of things, be they events, qualities, objects, or persons, have to be regarded, the mind is unable to grasp them separately, and life is scarcely long enough for comparison one by one. The similar ones are therefore classified and arranged in representative groups, and these classes and groups can then be contrasted. Thus Welsh are spoken of as being small and dark, whilst Scandinavians are regarded as tall and fair, because such qualities are presented by large numbers of people among these races respectively. If sufficient numbers are examined it is possible to estimate how dark or how fair, or tall or short, the groups may be, and how these qualities are associated, as will be discussed later.

These classifications and comparisons are largely the purpose of descriptive science, which, as it becomes more exact, applies measurement by methods of statistics, to deduce rules or laws applicable to fresh groups and classes, or even to all similar existing groups.

Quetelet, one of the pioneers of statistics, laid down four safe rules for guidance—

(1) Never have preconceived ideas as to what figures are to prove.
(2) In statistical work never reject a number merely because it varies widely from the average, or appears to contradict what you expect.
(3) Try to weigh and record all the possible causes of an event, and do not attribute to one factor what may be merely the result of several.
(4) Never compare data having nothing in common.

Graphic Methods.—It is only proposed to deal with statistics as a means of investigation. The use for propaganda purposes is

almost a branch of advertisement. For instance, at the Dresden Hygiene Exhibition, the greatest of the kind ever held, at the entrance to the section for cripples' education, a wax doll the size of a fourteen-year-old girl represented the number of cripples in the German Empire, another the size of a three-year-old infant, those requiring residential treatment. A 4-in. dolly was the number applying for treatment, and a toy bed 2 in. long represented the number of available beds. Methods like these are of great value for public education or appeal, but rather beyond our present range. Often the first steps, as it were, in statistical research can be done graphically. By an appeal to the eye facts can be presented which in figures might produce little impression.

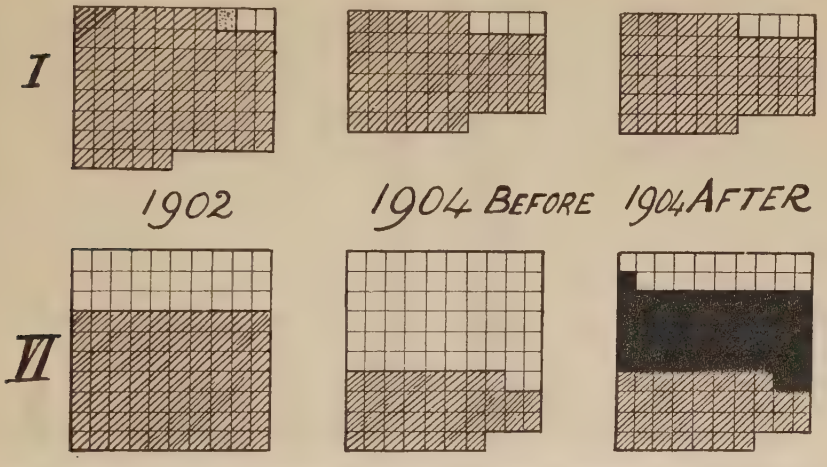


FIG. 157.—MEASLES RECORDS OF TWO CLASSES, EACH SQUARE A CHILD.

Plain squares not suffered, stippled unknown, cross-hatching already suffered, black went down in epidemic.

Thus, in an early enquiry into the condition of certain schools as regards measles, the condition of the children in the infant department had been noted as to whether they had previously suffered measles or not. Each child was represented on a diagram by a small square, which, if it had suffered measles, was shaded; if doubtful, dotted; if never suffered, left plain. When an outbreak of measles occurred, each case was blocked in black. The result in two classes was shewn as in Fig. 157, demonstrating the absence of spread in one class, as compared with the other, at an interval of three weeks.

Another way in which outbreak in a school may be set out clearly is to take a horizontal base-line A B, and from the left-hand end mark off distances, say, a millimetre each, to represent days during the period to be considered. These may be numbered

according to date of the month. For each case absent for the first time on any date, a space vertically of 1 mm. is marked off on that date above the base. On the vertical A C, a scale of numbers can be marked off. These proceedings are illustrated by a figure shewing an outbreak of measles in an elementary school. The first case absent on a Tuesday, the 3rd of the month, was missed for a week, when on the 10th two children were absent from measles, and the next day five. No cases are entered on the 14th and 15th, Saturday and Sunday, on which the school was closed.

The relation of two series of measurements can be expressed by using the abscissæ (horizontal measurements from A) for one set, here intervals for days, and the ordinates (vertical measure-

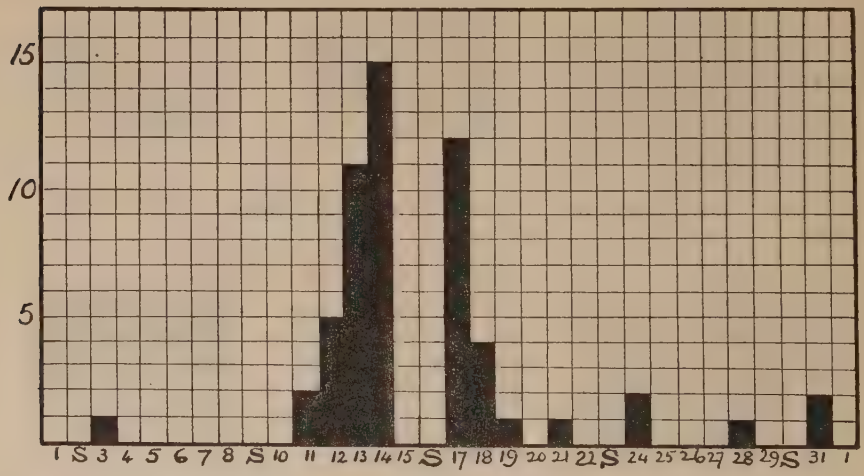


FIG. 158.—OCCURRENCE OF ABSENCES FROM MEASLES OUTBREAK IN SMALL VILLAGE SCHOOL.

ments from A) for the other set, here numbers of cases of measles daily notified.

For the purposes of these diagrams, squared paper is useful either in centimetre or millimetre squares, or even in the so-called logarithm paper for finer measurements. In arranging such a chart the usual geometrical convention is adopted of taking O, the bottom left-hand point, as origin. To save waste of space in working, the range of observations in each case has to be noted. If school children only are being dealt with, it is unnecessary to begin at O with birth, and mark along abscissæ corresponding to 1, 2, 3 years of age. The range of the measurements should be considered.

The first age marked should be a little lower than the lowest to be recorded (7 years), and the highest will be 14 years for elementary school children. If the other measurements are, say,

heights, it is unnecessary to include more than those below the lowest or above highest for the ages, say 100 to 160 cm., or, as there may be a few extreme cases, the scale might commence at 85 and extend to 185 cm. to be on the safe side.

Facility in making such charts is of first-class importance to all who would observe accurately, and deduce results rapidly. In giving a final representation, it is always advisable to shew the whole measurements by including the zero lines of diagrams.

The same chart may be used for two or more sets of measurements by a little ingenuity, if the units are carefully chosen. Where,

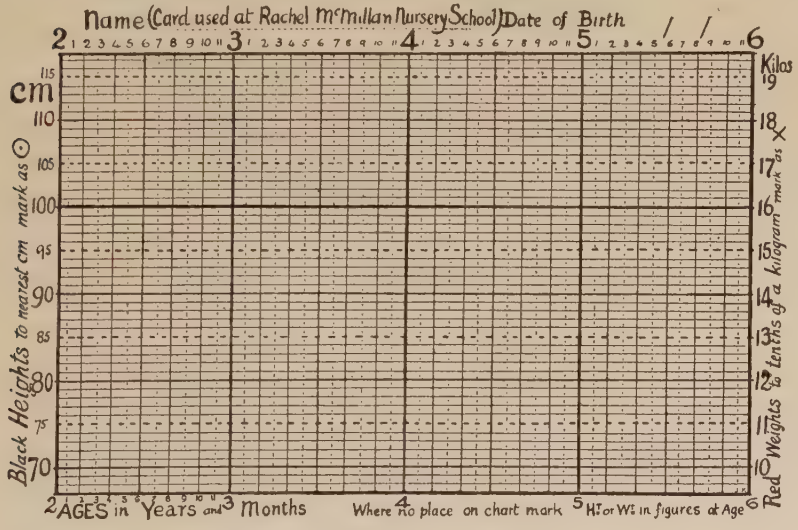

Name (Card used at Rachel McMillan Nursery School) Date of Birth
cm
Kilos
Black Heights to nearest cm mark as ⊙
Red Weights to tenths of a kilogram mark as ×
AGES in Years and Months
Where no place on chart mark
H or W in figures at Age

FIG. 159.—CHART USED FOR RECORDING WEIGHTS AND HEIGHTS AT DIFFERENT AGES IN THE RACHEL McMILLAN NURSERY SCHOOL.

for instance, in open-air school children the ages in years and months can be represented horizontally by abscissæ, whilst the vertical ordinates in one case may be used to represent heights according to a scale marked on the right-hand side of the chart ; the weights may also be charted vertically in accord with another scale marked on the left-hand side, and corresponding to kilos. Such a chart used for nursery school children in London is printed on a card 6 × 9 in.

In this chart, instead of marking off the values by millimetre squares of a column, a dot is made for convenience at the point where the abscissæ and ordinates representing its value would intersect. The dot should be quite small and, if necessary, a ring can be drawn round it. Dots are here used for heights. Or a small cross might be made whose intersecting centre corresponds

to the point measured. Such crosses on the chart are here used for weights.

Sometimes it is useful to determine the values at intermediate ages, say on the birthday, when age groups only are given; or one child out of a number who are being weighed every fortnight may have been absent on one occasion. It is useful to be able to interpolate a value closely approximate to the real value.

Thus the heights of a set of London boys, grouped as age last birthday 7, 8, 9, 10 was 116, 120·6, 125·4, 129·8 cm. respectively.

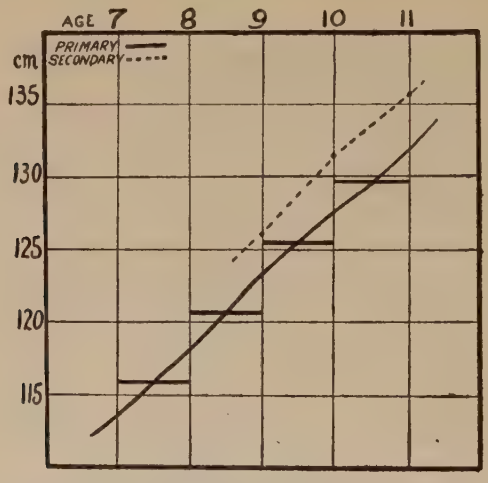


FIG. 160.—COMPARISON OF BOYS' HEIGHTS, REDUCED TO THEIR BIRTHDAYS.

Another group of secondary school boys on their 9th, 10th, and 11th birthdays measured 126·2, 131·6 and 135·7 cm.

To compare these groups in height, a chart can be made for the London boys.

The group aged 7 last birthday is represented by the part of the column cut off below the horizontal line opposite 116, the next for eight-year-olds by a column of 120·6, and so on. If now a curve be drawn to cut all these horizontal lines about their centre, and to cut off from each column as much above the horizontal lines as below them, then this curve will represent, as by the even line on the diagram, the general trend of growth, and the points where it cuts the vertical ordinates through the birthdays will give near values for heights on the birthdays 7, 8, 9, 10, 11 as 113·9, 118·2, 123, 127·6, and 132·3 cm., much below the measurements in secondary schools with which they were to be compared.

Neither the steps and stairs lines, nor the dotted line, represent the real facts, they only give summaries spread over the whole years of growth and integrated into these average growths. With

shorter periods of observation, as for instance, a monthly record of growth, a seasonal variation would appear, only noticed on such finer analysis.

Each step, however, is an average for that group. Also it will be seen later that these averages may not be quite correct. One of the evils of much statistical work of the present day is that averages are taken from masses whose units are not homogeneous enough. For this reason many of the results of advanced statistical methods give almost farcical results, unlike things being taken as equal. Another common fault in school-work is averaging selected and unselected groups together. An instance taken from a County Council Report gives proportions of rheumatism and chorea, in a table—

TABLE 105.

	Boys.	Cases.	Girls.	Cases.	Total Percentage.
Entrants	1657	35	1625	21	1·71
Leavers	1904	159	1942	244	10·48
Specials	500	38	602	61	8·98
Total	4061	232	4169	326	6·87

The entrants and leavers each form a group only differing in ages, but they are unselected in regard to health. Whereas the specials are of various ages, and all present some condition of ill health. The summed average, 6·87 per cent., is therefore a meaningless number of no value as a ratio.

The commonest form of diagram used in this arithmetical distribution, where each division, horizontally or vertically, represents the same amount on the scale, is sometimes spoken of as an arithmetical grid. Where one has to represent some numbers in units, and others in, perhaps, thousands, a distribution of the scale in logarithmic intervals is useful—the arithlog grid. Where ratios are being handled the arithmetical grid does not give true comparisons ; for instance, a reduction of 2 from 20 to 18 would shew at the same time and at the same rate if it were a reduction from 200 to 198, and yet in the one case it is 10 per cent. and in the other only 1 per cent. If set out on the arithlog chart the difference would be obvious.

Set out on an arithlog, rates at once display variations to the eye. An ascending line means increase at uniform rate, downwards means decrease either uniform if straight or increasing if curved down. Two horizontal lines represent ratios that remain constant, whilst sloping, or curving up or down, but parallel, the ratios in

two lines are varying at the same rate ; if separating, the difference in ratios is increasing, and vice versa. The subject is well set out by Pearl (*Medical Biometry*, 1923. 125). Examples of its use are found in Figs. 19 and 123.

Tabulation.—When like cases are put together so that their frequency of occurrence becomes noticeable mere analysis of a statement into tabular form will bring facts to light which might otherwise remain unnoticed. Thus in a recent enquiry by the Invalid Children's Association aid into the number of children and crippled persons in a large southern seaport town cases were tabulated according to the age of onset. Of 14 deformities all had occurred before one year of age ; of paralyses, 66 had occurred in the first four years of life and only 6 later ; of tubercular disease only 18 were recorded in the first four years of life and 29 later ; whilst in the last group, " all other diseases," all started over ten years of age. When these cases were set out with the age of onset under the year of birth, they were irregularly scattered, except the cases of infantile paralysis, which numbered half the total (66 out of 136), and were distributed as follows, the figure giving the actual age last birthday against the year of onset—

Table 106.

SHEWING YEAR OF BIRTH AND AGE OF ONSET OF POLIOMYELITIS IN CRIPPLED CASES (1919).

Year of Birth.	Age Last Birthday in Year of Onset.	Number of Cases falling in Year.
1902	0	1
1903	—	0
1904	3 2 0	1
1905	0 1 7	1
1906	0 2 5 1	3
1907	1 0 4 2 8	3
1908	3 1 3 3 3 9 9 0	3
1909	2 2 2 2 2 4 2 2 2 2 2 2 2	2
1910	0 1 1 1 1 0 1 1 2 1 1 1 1 0 1 0 2 1	4
1911	2 0	30
1912	1 0 0 1 1 5 2	5
1913	3	5
1914	0 1	2
1915	3 2 1	2
1916	2 0 3	3
1917	No returns	4+
1918	No returns	2+
1919	No returns	1+

Here, by setting out opposite each cripple's year of birth, the age last birthday, there appears, on assigning these cases to the respective year of occurrence, an exacerbation of disease in 1911

as the cause of nearly half the cases, for it may be that as the analysis only goes by years the real number may have been 36. The evils of an outbreak of poliomyelitis are at once evident, as is also the need of establishing movable or temporary schools dispatched from a centre to deal with a locality affected. By proper specialized early treatment only can much of this crippling be avoided. Yet without this tabulation the closely related origin might have escaped notice, and the urgent need for a movable unit for dispatch been less apparent.

Preliminary Classification.—The individuals or objects which constitute a group must have some quality in common. The classification is into those who have the quality, and those who do not have it. No others come into consideration.

In the case of children separation must be made by sex. In all qualities at school ages, take as example cleanliness of hair, sex is such a primary distinction that, if omitted, any classification of cleanliness where it is not indicated will be worthless for comparison with other groups.

The next division is by age, and in children physical and mental attributes usually vary so greatly with age that classifications neglecting it are worthless as regards individual qualities, and useless for comparison between groups. Indeed, as will be seen later, calendar age is often not enough in some of these enquiries. In some of our Colonies and in America, colour is almost a necessary grouping. Racial differences, too, shew where Semitic and Western European are in contrast, and may be sufficient to vitiate comparisons.

Sex, age, and race, then, are everywhere primary distinctions which must never be neglected in statements of the hygiene of growing individuals, if these statements are to be of scientific value.

Control Observations an Absolute Necessity.—There is another qualification which is frequently neglected, especially in medical statistics. The selection of statistics of a particular class are taken, and assumptions from that class, or for that class, are made in comparison with the general population, without having taken particulars for this general population. In other words, there has been no control observations on a normally distributed population.

In an observation on 3,009 Boston children who presented anæmia, 2377 were in rooms where the temperature was 69° F. or over, 321 in rooms with 68° F., while only 235 were in rooms between 64° and 67° F. As there is no statement as to the number of rooms at these respective temperatures, the figures afford no basis of judgment and are valueless.

Statements are made as to the intelligence quotients of criminals or of prostitutes or some selected class without regard to the general

population, and the consequence is that the deductions are often incorrect or overstated.

The dramatic success of open-air schools as shewn by physical measurements was considerably discounted when measured against ordinary school children for the same period. The nutrition classes in New York appeared more successful in the Autumn than in the Summer because they were compared together and normal controls not taken. The precaution of control experiments or observations can never be omitted in any fresh observations undertaken on children.

Definition of Working Units.—Whilst strictly the most accurate, yet it adds enormously to the trouble of practical working, if central values are taken as the International Anthropometric demand would have; that is to say, if all cases measuring within half an inch above or below 57 in. are recorded as 57 in., whilst $57\frac{3}{4}$ in. would be recorded as 58. If one is working graphically without using such central figures, the correction comes in automatically on the chart.

Measurements to the nearest centimetre, to the nearest pound, to the nearest birthday, should therefore be avoided in practice as almost unworkable except in skilled hands. It also leaves the first six months of life in the air.

Whenever a value of any measurement for an age is given, there should be absolute clearness as to what is meant to be included in the group. Where age last birthday is meant, it should be indicated by an Arabic numeral with a dash after it, as used in this sense in the Registrar-General's Reports, meaning, thereby, say, the group aged 10 last birthday as (10–).

Where a value is given for a definite age on or at a birthday, as is often done in quoting figures in tabular form—especially if obtained graphically or taken from a chart—the Arabic numeral should be used with a full-stop after it (10.). This distinction is important as the measurement in growing children, at any rate, taken at 10., differs by six months' increment from heights or weights taken for 10– years old group, a significant amount in comparisons.

Many tables and statistical records are confusing in practice from neglecting these distinctions, and although internal evidence may sometimes be useful, there is often so much uncertainty that much reported work has to be rejected for purposes of comparison through this defect. Even the almost classical paper on heights and weights of Glasgow school children, where ages were taken to the nearest birthday, erred in comparing these with British Association tables made up on age last birthday, therefore averaging half a year more of growth. These same Anthropometric Standards, which do not represent an average of any English population, are

used still for comparisons. For instance, in the *Edinburgh Report* for 1918, there are printed various tables of which one may be given.

TABLE 107.

BOYS' AVERAGE HEIGHT IN INCHES.

Average age in years ..	5 years 2 months	9 years 7 months	13 years 10 months
Numbers examined ,,	1359	1686	1275
AnthropometricStandard	41·0 in.	49·7 in.	56·9 in.
Edinburgh average ..	41·7 in.	49·1 in.	56·3 in.
Difference	0·7 in.	0·6 in.	0·6 in.

The five-year-olds are three months younger, the 9's one month older, and the 13's four months older than the so-called Standard Ages, and the differences noted are thus wholly erroneous as quantitative expressions.

Worse things are done, as in many M.O.H. Reports, when measurements of secondary school children are compared with " Standards " derived from elementary schools. In the instructions to Medical Officers for School Inspection in London, the eight-year-olds, in the year 1924, those born in 1916, are to be examined in the Spring and Summer. The twelve-year-olds are those born in 1912, to be examined in the Autumn and Winter. The results differ not by four years, but from the effect of this selections by $4\frac{1}{2}$ years in eight- and twelve-year-old groups.

Compilations claiming authority respecting such qualities as cleanliness, rates of growth (even in infants), visual or aural defects, too frequently err in neglecting sex and age distributions, or from their indefinite statement of these are not worth a tenth the value they would have had if clearly defined in reporting. The English Board of Education Reports are weak here on their scientific side.

After these primary classifications, there may be considered in each group any particular quality to be assessed. As a rule, there are continuous gradations in the quality, if large numbers are being dealt with. All qualities of living beings tend to a normal condition, which the majority attain ; but from chance conditions many vary a little, either falling short of, or going beyond, the normal. Their numbers are distributed, as will be seen later, according to what is known as the law of error.

Sometimes these gradations are variable qualities which can be numerically stated with considerable accuracy, as in dealing with physical measurements such as height, weight, strength of grasp, range of hearing, speed of walking, number of mistakes made, or taps recorded in the minute, and so forth. Other qualities are not so easily expressed. Mere attributes may not be measure-

able in figures. Cleanliness, attention, condition of nutrition, the state of the tonsils, and other similar matters may be impossible to masses numerically and difficult to classify satisfactorily. They require some categories standardizing into comparative scales, so that observers may work in approximately equal fashion, and with comparative exactitude.

Personal Equation.—For all this kind of work, too, the personal equation of the examiner should be taken into account ; for instance, some photographers in determining an accurate exposure, usually over-expose their plates, others habitually under-expose, although both are endeavouring to obtain an equal result. So, too, in medical affairs. Some take rather emotional views, whilst others tend to a *laissez-faire* attitude. There will always be optimists and pessimists, but for good work, observers should try to adjust themselves to equal standards with known good workers.

The categories for observing qualities not numerically measurable are usually stated in five grades : (1) excellent, (2) very good, (3) good or normal, (4) fair or subnormal, (5) bad. But these scales are only suitable for the coarsest pioneer work, or mere rule-of-thumb separation for practical treatment, and are usually only successfully applicable by their inventor, or, at any rate, personal to each user ; unless by careful observation the doctor has adjusted his bias, already referred to, or has definite categories or rules to work to, as suggested in the paragraphs on nutrition.

Categories should be arranged, if possible, so that there may be in any enquiry a suitable distribution of the grades of quality under each of the five classes. An ideal arrangement would include about 40 per cent. in the normal, 20 per cent. in the sub- and supra-normal groups, and 10 per cent. each in the excellent and bad groups. Unfortunately, such even distributions are scarcely possible, and so-called " Standards " are of the vaguest and most ill-defined classification in many cases. Groups (1) and (5) usually tend nearer 1 per cent. than the desirable 10 per cent. for descriptive work.

Undistributed Zero.—Another difficulty in the differentiations is that the condition may only have departures noted in one direction. Visual acuity, for instance, is only recorded as $\frac{6}{6}$ or worse, but if properly distributed, there are cases of $\frac{6}{5}$, $\frac{6}{4}$, or even $\frac{6}{3}$ to be recorded.

Hearing, heart disease, and so on are all similar cases where 60 to 80 per cent. or more are put into the normal, which includes classes 1, 2, and 3, all undistributed ; and then only very few, perhaps 1 or 2 per cent., come under class 5 (bad), and there is always difficulty in defining class 4.

As the doctor continues at work, hour by hour, and day by

day, his critical judgment gets more and more lenient, and class 4 is diminished towards normality. Indeed, in the early days of school inspection the late Sir Victor Horsley conducted a semi-political campaign against certain economical methods of school medical inspection of which he did not approve, basing it on the increased results of classes 4 and 5 together in such cases as ear disease, and neglecting the fact that class 5, the only one then of practical importance in the connection discussed, was equally large with either method, so that for the practical purpose required the more economical method was just as good, and one-fifth the cost.

In describing or handling these classes or groupings, there is first this statement of individual facts or units which make up the groupings. It is here that the layman falls short who handles masses of results or figures with expert knowledge of methods, but not such knowledge of the differentiation of his units. Often units hardly similar or comparable are grouped from the outset as if they were all of identical value.

The causes of blindness in London school children were first carefully noted in 1902, and some 42 per cent. were assigned to the results of ophthalmia neonatorum, with 4 or 5 per cent. doubtful. In the course of years, the composition of the blind schools became altered through the inclusion of many myopes, and semi-blind from other causes, so that the percentage of children in the blind schools due to ophthalmia neonatorum fell by 1925 to 19 per cent. This decrease was not wholly due to improved treatment in infancy, but partly to the inclusion of other cases previously passed over.

When units are arranged in groups, then numbers in each group can be tabulated, as in the first example of poliomyelitis cases on page 830, and further examined.

Usually the facts are recorded on separate cards for each individual classified. This should always be done when examining large numbers of children.

A useful device at the outset, where one side of the card is important, is to snip off the top right-hand corner of that side; by this labour-saving method the front side of the card can always face the worker. The cards are at once distributed in sexes by having two colours—blue for boys, and virgin white for girls. Red or pink cards are irritating to work with, and should be avoided. Nothing is here said about methods of later analysis by such aids as the Hollerith machines.

Frequency Tables.—As illustrating the use of tabulations, a certain enquiry on 8841 children may be referred to. Leaving the boys out of account, there were 4164 white cards of the girls. These were distributed into sets according to the age last birthday. This gave the totals shewn at the bottom of the table.

It was required to find how the growth and school capacity

of the children were related, so now these age groups were each distributed into the classes or standards in which the children were in regard to school.

When this was done they were tabulated as in the middle part of the table.

On examining this frequency table, it is noticeable that if any row of figures in the standards is taken, these tend to rise to a maximum, and then to fall again, and that the largest figures are the groups nearest this maximum. In the case of Standard IV, for instance, they rise 1, 11, 98, 251, 181, 79, 39; or if the ranks are taken by age the same thing occurs, thus for age 10–, the rise is 19, 33, 234, 251, 94, 12. This illustrates what has been noted,

Table 108.

FREQUENCY TABLE SHEWING DISTRIBUTION OF 4164 LONDON ELEMENTARY SCHOOL GIRLS, ACCORDING TO AGE LAST BIRTHDAY AND SCHOOL STANDARD.

Age last Birthday ..	7–	8–	9–	10–	11–	12–	13–	14–
Standard I	228	139	54	19	—	—	—	—
II	88	296	147	33	17	9	—	—
III	11	133	339	234	118	52	15	—
IV	1	11	98	251	181	79	39	—
V	—	—	8	94	237	162	125	9
VI	—	1	1	12	81	196	194	41
VII	—	—	—	—	9	75	214	113
Totals ..	328	580	647	643	643	573	587	163

that qualities tend to accumulate about a normal. In the case of Standard IV it is for most about the age of 10, and in the case of the ten-year-olds most are in Standard III or in Standard IV, the normal would lie between them if there was any finer gradation. If the table were set out graphically these numbers would lie approximately in a certain relationship, and if the total numbers were very large and gradations small enough each set would lie on a curve known as the curve of error.

Averages.—Returning to the groups of cards the heights of the children in each of these groups were noted from the card, and the total heights of the whole group added together, and divided by the number of children in the group, giving the average height of the group.

To determine the average height of one of the groups, take girls aged 10 last birthday and in Standard IV, for whom there were 251 cards. The lowest height was 114 cm., and in this group

was only one card; there were gradually increasing numbers in each height group, till at 130 cm. there were the cards of 20 girls, and at 131 cm. also 20, then tailing off in numbers till the two tallest children were one in the 148 cm. and one in the 152 cm. groups.

For convenience in practical working they should be tabulated with the heights 114 . . . 130 . . . 152 in the first vertical column,

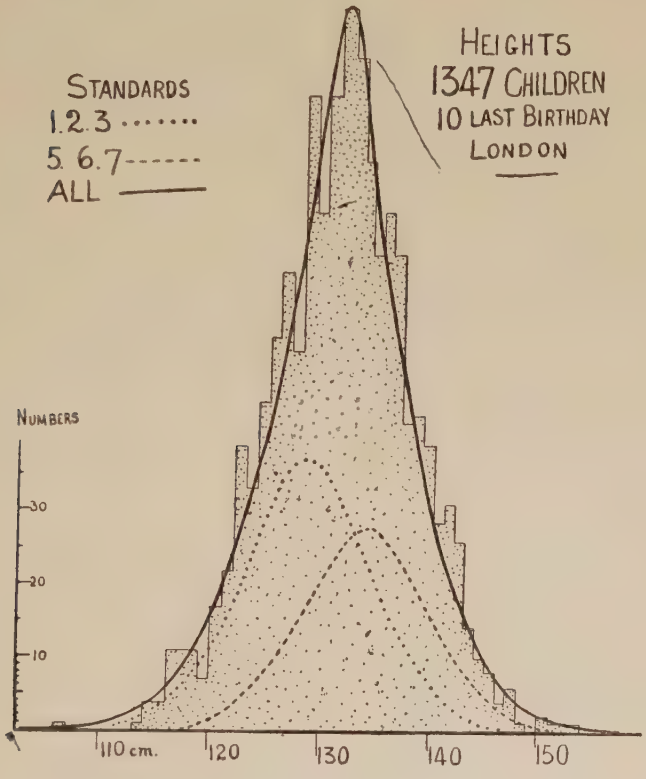


FIG. 161.

and the number of children in each height group given in the second column. An example is set out in Table 110.

Adding together the aggregate heights of the girls in this group the sum was 33,156 cm., and dividing by 251, the number of girls in the whole group, the average height of 132·1 cm. was obtained. So far as this example is concerned it would be for 1 of 114 cm. . . . 20 of 130 cm. . . . and so on.

$$\frac{1 \times 114 + \ldots + (20 \times 130) + (20 \times 131) + \ldots + (1 \times 152)}{251} = 132{\cdot}1$$

or, in general terms, $\frac{\Sigma(h)}{N}$, where $\Sigma(h)$ represents the sums of all the individual heights and N the number of observations.

For other groups these average heights may be tabulated as follows—

TABLE 109.

SHEWING THE AVERAGE HEIGHTS OF GIRLS BY AGE AND STANDARDS.

Girls.	7-	8-	9-	10-	11-	12-	13-	14-
VII	—	—	—	—	145·0	145·4	150·0	154·2
VI	—	—	132·0	135·1	138·9	145·1	148·5	153·1
V	—	—	130·7	133·5	138·7	140·8	146·2	151·4
IV	120·0	125·2	129·5	132·1	135·8	139·7	142·8	—
III	117·3	123·1	126·3	129·2	131·1	135·7	136·8	—
II	117·2	121·5	122·3	125·8	132·6	132·4	—	—
I	110·1	115·9	124·2	125·4	—	—	—	—

By this statistical statement it becomes obvious that for children of the same age last birthday the higher their standard in school the greater is their average height ; or big children are generally more advanced in school than small children of similar ages. This table can be still further checked, and corrected to greater accuracy, as will be shewn for the ten-year group on page 844.

A quicker way to determine the average is to select by inspection an arbitrary centre as near the middle as can be judged, and then correct it.

To prevent any confusion with the girls just used, take a fresh example in the heights of 635 boys, of a group B, aged 11 years on their last birthday. First make a column of the dimensions, in this case heights in centimetres, beginning with the lowest, 113 cm., and passing seriatim to the highest, 157 cm. The table is abbreviated to save space.

Having entered the column of dimensions, now, against each dimension, put the number of boys (Z) in a second column, corresponding to their heights. Next, inspecting the rise and fall of numbers in column Z, choose the dimension likely to be nearest the average. In this case 136 was taken. Place in the next column (X) all the deviations from this average ; for instance, the deviation of 135 is -1, of 137 is $+1$, whilst for 114 it is -22. Multiplying the number of cases (Z) by their deviation (X), the column ZX is formed, the numbers in which are positive or negative, according as to whether ZX was above or below the arbitrarily chosen average 136. Taking these numbers, there were 1761 units negative and 1599 positive, added algebraically they give a total of 117 negative units. This, divided by 635, the total number of observations (boys), gives $-0{\cdot}18$, which has to be subtracted from the arbitrarily chosen unit 136, to give $136 - 0{\cdot}18 = 135{\cdot}82$ cm. as the real average.

Standard Deviation.—This particular group B, of 635 boys of 11 years old last birthday, averaged 135·82 cm. Another group, D, of 440 boys, also aged 11 last birthday, averaged 133·4 cm.; whilst a third group, C, of 386 boys, of similar age, averaged 132·54 cm. It will be obvious that the average height does not give every information, as in one group all the cases might be

TABLE 110.

FREQUENCIES. HEIGHTS OF LONDON BOYS AGED 11 LAST BIRTHDAY.

Dimensions.	Number of Individuals, Z.	Deviation from Chosen Centre, X.	ZX.	ZX^2.
113	1	−23	−23	529
114	—	−22	—	—
115	—	−21	—	—
116	1	−20	−20	400
⋮	⋮	⋮	⋮	⋮
135	37	−1	−37	37
136	50	0	0—1716	0
137	34	+1	+34	34
138	36	+2	+72	144
⋮	⋮	⋮	⋮	⋮
153	3	+17	+51	867
154	1	+18	+18	324
155	—	+19	—	—
156	—	+20	—	—
157	1	+21	+21+1599	441
	635		−117	28,753

close to the average, whilst in another they might be considerably spread out. The amount of this deviation has to be measured.

It might be expressed as the average amount of all the deviations (d) from the centre, also called the mean deviation. A.D. or m.v. $= \frac{\Sigma (d)}{N}$.

The most generally used expression, however, is called the standard deviation, represented by the small Greek letter (σ) sigma. This is the square root of the average of the squares of the individual variations from the centre: $\sigma = \sqrt{\frac{\Sigma (d)^2}{N}}$. It will be seen later that it is really a standard of measurement.

In the case under consideration, beginning with the top of the table, it would be set out as—

$$\sigma = \sqrt{\frac{1\times(-22{\cdot}82)^2+1\times(-19{\cdot}82)^2+\ \ldots\ 37\times(-0{\cdot}82)^2+34\times(0{\cdot}18)^2+\text{etc.}}{635}}$$

The troublesome arithmetic here involved can, however, be much shortened by the following process.

Taking the boys of group B, the column ZX^2 is formed; here all values become positive from the squaring. Adding up the values, 28,753 is obtained ; divided by 635, the number of observations, the result is 45·2835. This value, however, is related to the arbitrarily chosen centre 136, and must be corrected to the true average by subtracting the square of the difference already found between them; that is, the square of $\frac{ZX}{N}$ or $(0{\cdot}18)^2 = 0{\cdot}0324$. Subtracting this from 45·2835 for the arbitrary centre, there is obtained 45·2511. This the square of the standard deviation relating to the true average $\sigma^2 = 45{\cdot}2511$, therefore $\sigma = 6{\cdot}7268$.

Probable Error.—If there are only a small number of boys, a larger or smaller boy might make a considerable difference in the average. With larger numbers, this risk is diminished considerably, but a doubtful amount always remains which is called the probable error. The average, as found, may really be greater or less than that given above by the amount of this probable error, and in stating an average it should be stated as, average $\pm$ probable error.

The probable error is $0{\cdot}67\frac{\sigma}{\sqrt{N}}$, where σ is the standard deviation, and in the case being considered this is $0{\cdot}67 \times \frac{6{\cdot}7268}{25{\cdot}1992}$ $= \pm\, 0{\cdot}18$. Although this happens to be the same figure as $\frac{ZX}{N}$ on a previous page, it has nothing to do with it, being merely a coincidence.

The accuracy of the result depends only to a small degree on the accuracy of individual measurements, compared with what it does in the numbers measured. Indeed, the only measure of the accuracy of a figure derived from honest statistics is its probable error. With small numbers, this is necessary to be known before the result has any value for comparative purposes.

This probable error is such that half the cases observed will lie within this distance of the average. The decimal 0·67 is deduced mathematically from the properties of the normal curve of error described later.

Formerly an idea of the form of distribution of the assortment, whether the values were closely grouped round the average, or

whether they were widely spread out, was conveyed by curves such as these being roughly described by determining the median, that is, the number above and below which lay an equal number of cases. Then the number could be stated above and below which were equal numbers of all those below the median. This was the lower quartile ; similarly with the numbers above the median giving the upper quartile.

A method of percentiles was described by Galton in *Natural Inheritance*, when the whole series of values was ranged, so that at a point P the percentage of cases p fell below P, and $100 - p$ fell above it. Then P was a percentile. Thus, if P was chosen at the 25th percentile so that 25 per cent. of the cases were below it, then P would coincide with the lower quartile. Similarly, the 50 percentile would be the median.

In practice deciles are generally fine enough. Deciles were used by Hawkins in his paper on the growth rates of Haileybury boys. Percentiles might be useful in dealing with mental assessments by the Binet Scale. There, backward groups run to about 12 or 15 per cent., but feeble-minded only to about 2 per cent.

In normal distributions, as in the analysis of a large number of individual measurements, of height say, the average is the central figure in the table of frequencies. It is the figure, mode, at which the largest number of cases occur, and is also the figure, median, on each side of which lie half the cases. Where, instead of the common symmetrical distribution, it is irregular, the average as found above by arithmetical computation, may differ from this normal curve of error in not coinciding with either mode or median ; which two may also differ from each other.

An easy way to determine the probable error follows from the statement above that 50 per cent. of the cases will fall within limits of the probable error from the average.

If the frequency table is taken, and 25 per cent. of the cases counted from each end, the two dimensions are found corresponding to the 25th and 75th percentiles, then the probable error is half the difference between these two dimensions.

The most correct statement of the heights of the group B, of eleven-year-old boys, is that the average A_b is 135·82 $\pm$ 0·18 cm.

Another group, D, of 440 boys, was A_d equal to 133·4 $\pm$ 0·20 cm.

Whilst group C, numbering 386 boys, gave A_c equal to 132·54. $\pm$ 0·54 cm.

Significance of Averages.—The significance of the difference between these averages is determined by the relation of this difference to the square root of the sum of the squares of the standard deviation

of each group, divided by the number of observations in each group. It can be shewn that if the averages

$$A_d - A_b = \sqrt{\frac{\sigma_d^2}{N_d} + \frac{\sigma_b^2}{N_b}}$$

the odds are that the difference is due to chance. If

$$A_d - A_b = 2\sqrt{\frac{\sigma_d^2}{N_d} + \frac{\sigma_b^2}{N_b}}$$

the odds are 49 to 1 against chance ; if the difference is thrice the first amount, the odds are 1000 to 1 against chance, and with four times, about a million to one.

The same would hold with

$$A_d - A_c = 3\sqrt{\frac{\sigma_d^2}{N_d} + \frac{\sigma_c^2}{N_c}}$$

or any other combination. If the difference is three times or more, then there are disturbing factors present beyond any risks of chance or random selection.

In the example taken, $A_b - A_c = 135{\cdot}82 - 132{\cdot}54 = 3{\cdot}28$, and

$$\sqrt{\frac{\sigma_b^2}{N_b} + \frac{\sigma_c^2}{N_c}} = \sqrt{\frac{(6{\cdot}7268)^2}{635} + \frac{(7{\cdot}5352)^2}{386}} = \sqrt{0{\cdot}0713 + 0{\cdot}1471} = 0{\cdot}4673$$

and the difference of the averages is about seven times as much. For $\frac{3{\cdot}28}{0{\cdot}4673} = 7{\cdot}1$. So that the odds against chance causing this difference between B and C groups are many millions to one.

For A_d and A_b the difference is about six times, again millions to one against chance being the cause.

With groups D and C, however,

$$A_d - A_c = 0{\cdot}86 \quad \text{and} \quad \sqrt{\frac{\sigma_d^2}{N_d} + \frac{\sigma_c^2}{N_c}} = 0{\cdot}48$$

Now $\frac{0{\cdot}86}{0{\cdot}48} = 1{\cdot}8$, which gives the odds only about thirty to one against chance. This is not margin enough to establish a definite difference between them and exclude chance.

The average weights of these groups were $D = 29{\cdot}61 \pm 0{\cdot}11$ kilo, $B = 30{\cdot}67 \pm 0{\cdot}10$ kilo, and $C = 29{\cdot}28 \pm 0{\cdot}14$ kilo.

As has been shewn for any group, the odds are a thousand to one that any subsequent average from similar material will fall within $A \pm 3\frac{\sigma}{\sqrt{N}}$.

This can be shewn on a diagram by setting out the averages of

each group as centres, taking ordinates vertically as stature and weights as abscissæ horizontally. From the point thus found for each group, there is measured along the abscissæ in each direction a distance $3\frac{\sigma_w}{\sqrt{N}}$, and, similarly, for statures along each ordinate up and down $3\frac{\sigma_h}{\sqrt{N}}$ is marked. Drawing ordinate and abscissæ through the fresh points thus obtained, a rectangle is formed.

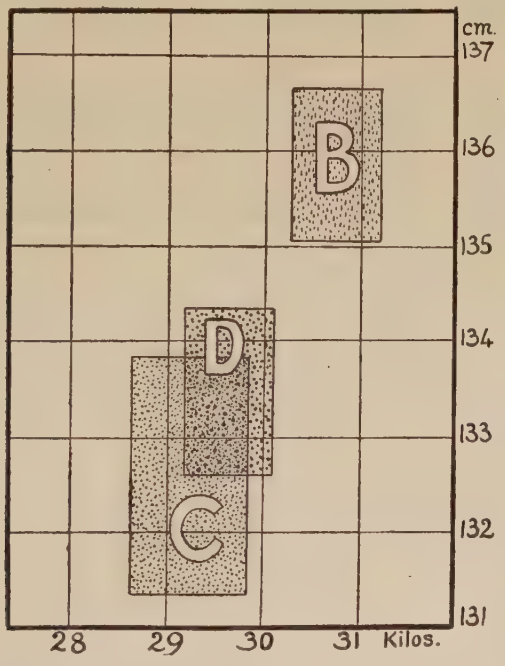


FIG. 162.—HEIGHTS AND WEIGHTS, ALLOWING FOR STANDARD DEVIATION, OF THREE GROUPS OF ELEVEN-YEAR-OLD LONDON BOYS.

Shewing significant difference beyond chance in case of group B, but mere chance difference between groups D and C.

Within it is a thousand to one that the average of any other chance sample will fall. If the average does not fall within this, then some other factor than chance is acting.

It has already been seen that the groups D and C, which overlap on the diagram, are not sufficiently differentiated to justify any conclusion that chance is not the cause of their variance; but B differs from them both. There is no overlapping here, and chance as the cause of the difference between B from high-class suburban schools, and D and C from schools in densely populated town districts is excluded. Fig. 162 gives these measurements as

set out graphically. A further detailed working out of a set of measurements is published on page 10 of the *Report of the Medical Officer (Educ.) to the L.C.C. for the year* 1907.

Returning to the first example quoted on page 838, it was stated that the table could be further checked to give greater accuracy. That table was given for girls; there is not space to detail the whole table, but the group of ten-year-olds can now be given with the full corrections, and, for the sake of comparison, that for ten-year-old boys is also given.

These measurements shew that the differences noted in the

TABLE 111.

SHEWING THE CORRECTED MEASUREMENTS OF TEN-YEAR-OLD BOYS AND GIRLS IN THE VARIOUS STANDARDS.

Sex.	Standard.	Average Stature in c.c.	Probable Error.	σ Standard Deviation.	Numbers Observed.	$\frac{\sigma^2}{N}$	Coefficient of Variation.
Girls aged 10–	I	125·25	±1·11	7·4283	20	2·7591	5·93
	II	125·76	±0·80	6·9599	33	1·4375	5·52
	III	129·43	±0·28	6·3561	233	0·1734	4·91
	IV	131·70	±0·25	6·0216	250	0·1450	4·57
	V	133·77	±0·39	5·6754	94	0·3427	4·24
	VI	135·08	±1·02	5·3132	12	2·3525	3·93
Boys aged 10–	I	128·27	±0·85	5·9942	22	1·6318	4·67
	II	126·25	±0·52	5·7061	53	0·6143	4·47
	III	130·02	±0·30	6·1139	183	0·2043	4·70
	IV	131·63	±0·24	6·0918	273	0·1359	4·62
	V	133·29	±0·33	6·1302	153	0·2456	4·60
	VI	135·53	±0·90	5·7532	19	1·7421	4·24

various standards are real, and that the possibilities of any random sampling may be left out of account.

The meaning of the standard deviation, being greater or less, is, that where there is more variation in the dimensions of the things observed, the deviation increases. The distribution of numbers of objects having the same average dimensions can be represented by the two curves F and G, but G is more scattered, and consequently σ_f is much less than σ_g. When any comparison between two sets of facts is attempted, it is the distribution of the deviations from the mean that is all important, not the actual measurements of the means themselves.

Here, too, it is to be noted that if the growth of these girls was represented by a curve based on the average stature, it would not be as correct as a smoothed curve based on this, and taking the probable error into account (p. 45).

Where the averages do not coincide, it is not possible to compare

the variation directly by the standard deviations, but, as Pearson suggests, a comparison can be made by reducing them to a common form. This is done by dividing each standard deviation by its mean, and multiplying by 100, which gives a quantity called the *coefficient of variation.*

Robertson illustrates by a numerical example the meaning of this coefficient of variation which is a ready measure of variability in that it is the percentage ratio of the standard deviation of the quantities measured to their average value. The standard deviation is the square root of the mean square of the deviations of the individual measurements from their average. For example, if five measurements should yield the values 3, 4, 5, 6, 7, the average value would be 5. The standard deviation $\sqrt{2^2 + 1^2 + 1^2 + 2^2} = 1{\cdot}414$, and the variability would be $\frac{1{\cdot}414}{5} \times 100 = 28$ per cent.

If five other measures were 13, 14, 15, 16, 17, the standard deviation would be 1·414 as before, but the variability is only 9 per cent. If, again, the measurements yielded 103, 104, 105, 106, 107, the variability is now 1·35 per cent.

Curve of Error.—Attention was drawn to the way the numbers in the frequency table of girls' ages and standards rose to a maximum, and then diminished. In Standard IV, for instance, for each year of age from seven onwards the numbers read : 1, 11, 98, 251, 181, 79, 39. In a large variety of observations in connection with school hygiene this form of distribution is found, and usually depends on a multiplicity of factors, practically amounting to chance causing variation from a normal. If these observations are in sufficient number, and the quality under observation is measured graphically along the abscissæ, and the numbers in each group of the quality set out as ordinate, a symmetrical curve would be obtained. This is known as the curve of error.

The average or arithmetical mean coincides with the mode or group having the largest number of cases. This mathematical curve representing the chance distribution of errors is not usually followed quite exactly. If the mental capacities of a number of individuals be measured by any means, it is found that if fine enough groupings be taken, the mean and mode do not coincide (Fig. 78). The curve is skewed—that is, it is larger or steeper on one side than on the other ; it is not exactly symmetrical. The measure of this skewness is—

$$\frac{\text{Mean} - \text{mode}}{\text{Standard deviation}} = \text{skewness of curve}$$

What it means in this particular case is that one cause acting unequally on certain of the cases has produced an effect on one side greater than on the other. Physiological variations would dis-

tribute the mental qualities in accord with the curve of error; but the effects of disease, more marked in the case of less intelligent families or individuals, all act in one direction to cause the skewing downwards.

Normal Curve of Error.—The normal curve of error or probability curve, to which most of the statistical distribution in school hygiene approximate, was developed about a century ago by the French mathematicians, Gauss and Laplace. It is described by the equation—

$$y = \frac{N}{\sigma\sqrt{2\pi}} e^{\frac{-x^2}{2\sigma^2}}$$

where N is the total number of units, σ, the standard deviation, and the other are the usual symbols.

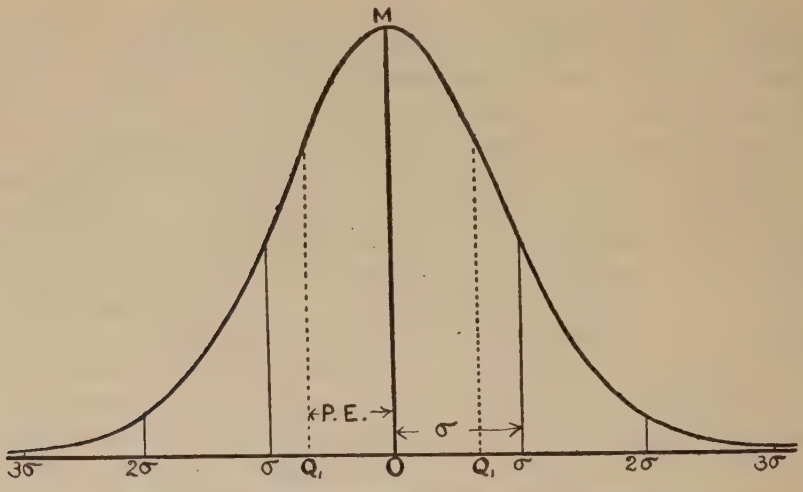


FIG. 163.—THE NORMAL CURVE OF ERROR.

M the median, P.E. probable error and Q_1 quartiles, σ standard deviation which measures the distribution.

The diagram shews some of the properties which are of importance. The central line M O gives the mean value, and the cases are equally distributed on either side of it. Measuring σ in each direction from O to σ_1, from which ordinates are erected, between these ordinates are included 68·26 per cent. of the cases. If from O the distance $O\,Q = 0{\cdot}67\,\sigma$ is taken, the ordinates (dotted) are quartiles and include 50 per cent. of the cases. This distance O Q gives the *Probable Error* (P.E.). Distances from O equal to $3\,\sigma$ give the points σ_3 ordinates, which include 99·73 (practically all) the cases, so that the range is just over $6\,\sigma$.

There are other varieties of distribution represented by different curves, but in these cases the effects marked are not from causes

acting on homogeneous material or population; for instance, the distribution of deaths at various ages gives a curve falling rapidly from birth to about eleven or twelve years of age, to again steadily rise. They are special cases, which must be handled graphically, or on general lines.

Correlation.—When high values (x) of one quality are associated with high values (y) of another quality, or vice versa, there is said to be correlation between these qualities. Where there is no such association, and the values of one quality do not vary in any way proportionately to the values of the other, so that there is no relation between them, the correlation is zero. Where unit change in one quality corresponds to unit change in the other, the correlation is complete, and positive or negative as the case may be.

The numerical value of this correlation varies from + 1, through zero to − 1, and is called the *coefficient of correlation*, usually expressed as r. Being simply a ratio, it is independent of any units of measurement.

$$r = \frac{\Sigma\,(x\,y)}{\mathrm{N}\,\sigma_x\,\sigma_y} = \frac{\Sigma\,(x\,y)}{\sqrt{\Sigma\,x^2\,\Sigma\,y^2}}$$

It is often referred to as the Bravais-Pearson or product-moment formula.

The second form of the equation is the most convenient for practical work.

As shewn in the above expressions, r measures the deviations of x and y from their means, in units of the standard deviations. Mathematically minded writers often express the relationship in a regression equation, or by a regression coefficient. If in a scatter diagram the line which best fits the means is drawn, its deviation from the line of perfect correlation shews the amount of *regression*. The equation of this best fitting or line of regression may be written $y = mx$, where m is the tangent of the angle of this line with the horizontal axis.

It can be shewn that $m = r\frac{\sigma_y}{\sigma_x}$, and this is the regression coefficient of y on x; similarly $r\frac{\sigma_x}{\sigma_y}$ is the regression coefficient of x on y.

The practical working out of an example to shew the determination of the coefficient of correlation may be useful, by determining the correlation between age and standard for the 4164 London girls for whom a frequency table (108) was given.

The table is set out as below. The columns are then added horizontally and vertically. The number that should fall in each group if the distribution were uniform through the standards,

as in the total, is then calculated by multiplying the sums of intersecting columns, and dividing by the total number, 4164.

This theoretical number is then placed below the actual figures; it is the second number shewn in some squares.

For the seven-year-olds in Standard I this was $\frac{440 \times 328}{4164}$ $= 346 \cdot 6$. In the fourteen-year-olds of Standard I none were actually recorded, but the theoretical number is $\frac{440 \times 163}{4164} = 17 \cdot 2$. The difference between the actual and theoretical number is then written down. It is the third number in the square. For the

TABLE 112.

Ages ..	7-	8-	9-	10-	11-	12-	13-	14-	Totals.
Standard I	228 346·6 118·6 14065·96 40·58	139	54	19	—	—	—	— 17·2 17·2 295·84 17·2	440
II	88	296	147	33	17	9	—	—	590
III	11	133	339	234	118	52	15	—	902
IV	1	11	98	251	181	79	39	—	660
V	—	—	8	94	237	162	125	9	635
VI	—	1	1	12	81	196	194	41	526
VII	—	—	—	—	9	75	214	113	411
Totals ..	328	580	647	643	643	573	587	163	4164

seven-year-olds of Standard I this is 118·6. These numbers are then squared, conveniently done by using Barlow's Tables of Squares. These squares are then divided by the theoretical number, giving in this case $\frac{14{,}065 \cdot 96}{346 \cdot 6} = 40 \cdot 58$. This is done throughout the table. All these quotients are then summed (χ^2), which in this case gave 3698·80 as the result. This is then divided by 4164, the number of observations, and the result—

$$\frac{\chi^2}{N} = \frac{3698 \cdot 80}{4164} = 0 \cdot 88828 = \phi^2$$

The coefficient of correlation between age and standard is found as—

$$r = \sqrt{\frac{\phi^2}{1 + \phi^2}} = \sqrt{\frac{0 \cdot 88828}{1 \cdot 88828}} = 0 \cdot 77068$$

The probable error is—

$$0{\cdot}67\,\frac{1-r^2}{\sqrt{N}}$$

This value is—

$$\pm\,0{\cdot}67\,\frac{0{\cdot}406}{64{\cdot}529} = \pm\,0{\cdot}00421$$

Sometimes correlation has to be measured between qualities not strictly measurable, but so long as they can be grouped as above, the relation can be set out.

In an analysis of 5708 boys aged 10 last birthday, the vision was distinguished as good ($\frac{6}{6}$), fair ($\frac{6}{9}$ or $\frac{6}{12}$), and bad ($\frac{6}{18}$ or worse). The standards were given ; it was possible therefore to ascertain

TABLE 113.

Standard.	Good Vision.	Fair Vision.	Bad Vision.	Totals.
I	50	28	14	92
	70·56	14·75	6·69	
	20·56	13·25	7·31	
	422·71	175·56	53·44	
	6·00	11·90	7·99	
II	205	80	36	321
III	1634	398	157	2189
IV	1695	284	148	2127
V	641	97	49	787
VI	134	26	11	171
VII	19	2	0	21
Totals ..	4378	915	415	5708

the correlation between visual acuity, using both eyes, and the mental intelligence as measured by school attainment.

In this table (113), the vision and standards are set out in groups, and treated exactly as in the case of the girls. The columns are added horizontally and vertically, then the theoretical distribution found by multiplying together totals of intersecting columns and dividing by the total number of boys.

For the groups of Standard I the groups thus got are 70·56 good, 14·75 fair, and 6·69 bad. These are written under the actual numbers ; then the differences written down, these last squared ; and, finally, the squares divided by the theoretical number in each group. Ultimately, the sum of all these quotients (χ^2) is obtained, and was 88·38, divided by the total number of observations, $\frac{\chi^2}{N} = \phi^2 = \frac{88{\cdot}38}{5708} = 0{\cdot}0155$, and from this r the coefficient of

correlation between visual acuity and school standard is obtained for

$$r = \pm\sqrt{\frac{\phi^2}{1+\phi^2}} = \pm\sqrt{\frac{0{\cdot}0155}{1{\cdot}0155}} = \pm 0{\cdot}1235$$

and the probable error of this coefficient is

$$0{\cdot}67\,\frac{1-r^2}{\sqrt{N}} = \pm 0{\cdot}007$$

Dr. Frank Shrubsall, who calculated this correlation, found various values for r for visual acuity, and school standard at different ages as—

r	9–	10–	11–	12–
Boys	$0{\cdot}120 \pm 0{\cdot}010$	$0{\cdot}123 \pm 0{\cdot}007$	$0{\cdot}113 \pm 0{\cdot}007$	$0{\cdot}133 \pm 0{\cdot}008$
Girls	$0{\cdot}159 \pm 0{\cdot}007$	$0{\cdot}123 \pm 0{\cdot}009$	$0{\cdot}130 \pm 0{\cdot}009$	$0{\cdot}120 \pm 0{\cdot}009$

Where the coefficient of correlation exceeds its probable error by three times or four times, chance is eliminated. Here the excess is so much that it shews a definite relation between visual acuity and school attainments.

Again, an example from the Sheffield smallpox epidemic of 1887–8 enables the correlation between effective vaccination and strength to resist smallpox, to be found as $r = 0{\cdot}769 \pm 0{\cdot}012$, a very high value, by setting out facts as in the following table—

Table 114.

Vaccination.	Power to Resist Present (Recovery).	Power to Resist Absent (Deaths).	Totals.
Scars present	3951	200	4151
Scars absent	273	274	552
Totals	4229	474	4703

There are cases of attributes where it is impossible or difficult to classify into groups as above. Suppose, for instance, that in a certain town there were 20,000 inhabitants, of whom 220 had red hair; whilst 400 were noted as having blue eyes. To investigate the relationship between blue eyes and red hair, only three class frequencies are given. Where n class frequencies are being examined, in this case $n = 2$, it is necessary to have given 2^n inde-

pendent frequencies, and here 2^n is equal to 4. From the data given, the table can only be stated as—

TABLE 115.

	Blue Eyes.	Not Blue Eyes.	Totals.
Red hair	?	?	220
Not red hair	?	?	19,780
Totals	400	19,600	20,000

The assumption that there is no relation between red hair and blue eyes being made the chance of any person having red hair is $\frac{220}{20,000}$, and of any person having blue eyes $\frac{400}{20,000}$; the chance of having both is $\frac{220}{20,000} \times \frac{400}{20,000}$, and among the total population this would give $20,000 \frac{220 \times 400}{(20,000)^2} = 44$ persons having both blue eyes and red hair.

The further details of this table could now be filled in on the assumption that there was no relationship between the two. If, now, any other values were actually found than the figures thus theoretically obtained, a relationship would exist which could be calculated as already shewn.

This 44 is the most probable value, and the observed value not coinciding, the values for each group obtained from the observed value is found, squared, and divided by the theoretical values; the results are added and divided by the whole number of observations. This value ϕ^2 is used to obtain the first coefficient of contingency, $c_1 = \sqrt{\frac{\phi^2}{1+\phi^2}}$, similar to the form already given for r, the correlation between the two attributes.

For correlation of presence or absence of traits, Yule gives a formula: $r = \frac{a\,d - b\,c}{a\,d + b\,c}$; a being the number of cases where both traits are present, b where first is present and second absent, c where second is present and first absent, and d where both are absent.

In using statistical methods we have to take things as we find them, and from this attempt to trace the influence of various factors. The physicist or laboratory worker can usually examine his factors by isolating their effects, and rendering all the others null or equal during the time of his tests.

It is possible to attain the same ends in a statistical way by the method of partial correlations, which determines the relations between two factors, supposing all the others made equal or stationary. Suppose, for instance, the relations of (1) height, (2) weight, (3) age, were to be considered in a mixed group, and r_{12} expresses the relation of height and weight, how far is this influenced by both being related to age ? If the correlation is r_{13} for height and age, then the correlation $r_{12 \cdot 3}$ of height and weight, when age is constant, can be obtained for—

$$r_{12 \cdot 3} = \frac{r_{12} - r_{13} \cdot r_{23}}{\sqrt{(1 - r_{13}^2)\,(1 - r_{23}^2)}}$$

and so for any number of attributes.

The actual calculations are very tedious, but can be lessened by tables. The general proposition is dealt with fully in Chapter XII of Yules's *Theory of Statistics*, and more simply in Pearl's *Medical Biometry*, 1923. 319. The method is becoming of increasing value in school-work, although hitherto it has not been applied by general workers.

The above methods include all likely to be required by the Medical Officer. For a number of processes used in educational psychology, special statistical works must be consulted.

INDEX

Abdomen, 59, 64, 233, 248
Accidents, 194, 224
Accommodation (Eye), 465, 488, 501, 505
Acts of Parliament—
  Blind Persons Act (1920), 542
  Children Act (1908), 422, 432, 730
  Education (Administrative Provisions) Act (1907), 221, 238, 633
  Education Act (1870), 180, 331, 588
  Education Act (1914), 180
  Education Act (1918), 180, 737
  Education Act (1921), 122, 180, 205, 303, 381, 397, 402, 422, 438, 534, 535, 543, 588, 593, 633, 636
  Education Act (Defective and Epileptic) (1899), 331, 381, 383, 397
  Elementary Education Act (Blind and Deaf) (1893), 180, 535, 588
  Elementary Education Act (Provision of Meals) (1906), 122
  Mental Deficiency Act (1913), 382, 383, 387, 389, 412, 414
  Offences against Persons Act (1861), 432
  Poor Law Emergency Provisions Act (Scotland), 122
  Vaccination Act (1906), 714
Adaptation (Eye), 464, 522, 796
Adenoids, 153, 226, 242, 457
Adenoma sebaceum, 403, 404
Adolescence, 281, 315, 326, 410
Age—
  Athletic, 88
  Chronological, 20–41, 832, 836
  Mental, 334, 353, 375, 387
  Physiological, 39, 136, 315, 378
Agraphia, 613, 621
Albuminuria, 161
Alcohol, 9, 310, 313, 321
Alexia, 613
Alopecia, 734
Alphabet, 562, 602
Ambidexterity, 625, 630
Amblyopia, 486, 500, 684
Anæmia, 114, 214, 268, 277
Anorexia, 109, 132, 255
Anthrax, 659, 788
Aphasia, 573, 598, 611, 621
Aphonia, 604, 654
Apparatus, physical, 87, 91, 168, 441
Apperception, 232, 476, 525, 544
Aprosexia, 232, 241
Articulation, 593, 604, 650
Asthenopia, 495
Astigmatism, 493, 505
Attendance, 593, 637, 698, 718
Attitudes (*see* Posture), 64, 160, 564
Averages, 44, 829, 836, 841

Babies'—
  Growth, 21, 154, 171, 439
  Mentality, 316, 355, 560, 599
  Performances, 155, 156, 444, 626
  Rooms, 91, 327, 439
  Vision, 454, 476, 486, 553
Backs, 67, 155, 158, 162
Balance, 86, 156
Basements, 745
Bathing, 93, 210, 242, 724
Baths, 441, 724, 725, 727
Bed wetting, 232, 377
Binet-Simon Scale, 112, 347, 348, 353
Birth, 38, 397
Birth control, 430, 649
Blackboard lighting, 525, 808, 820
Blackboards, 219, 523, 561, 812
Bleeders, 89, 236
Blind, 317, 454, 535–43
Blood pressure, 28, 72, 214, 267
Book slopes, 187, 547, 556
Books, 533, 556, 557
Boots, 170, 174, 176
Boy Scouts, 94, 420

Braille, 540, 623
Brain, 19, 313, 582, 598
Breathing, 54–60, 63, 230
Breathlessness, 70, 72, 89, 288
Brightness, surface, 526, 798
Brilliancy, intrinsic, 522, 797, 816
Buildings, 741, 746–63

Carbon dioxide, 764, 768, 776
Carbon monoxide, 792
Cardiac schools, 218, 286, 290, 292
Cards, record, 213, 731, 835
Care Committees, 111, 206, 635, 730
Caries, dental, 134, 136, 139
Carriers of disease, 664, 693, 695, 708
Catarrh, 108, 199, 212, 229
  Chronic dry, 233, 236
Cerebellum, 41, 304, 318
Cerebro-spinal fever, 586, 716
Certificates, 259, 383, 637, 722
Chalks, 554, 843, 850
Chance, 842, 843, 850
Character, 83, 326, 372
Charges, 122, 181, 205, 213
Charity, 121, 132, 184
Chest, 17, 55, 75, 164
Chicken-pox, 714
Chilblains, 172, 177, 178
Child—
  American Indian, 512
  Blind, 535–43
  Deaf, 44, 585–95
  Exceptional, 373, 376
  Nervous, 254, 371
  Overworked, 89, 126
  Phthisical, 247, 255
  Pre-school, 436–46
  Rickety, 31, 47, 144
  Single, 325, 326, 368, 443
  Superior, 28, 119, 373, 376
Chilling, 772, 788
Chorea, 271, 291, 413, 829
Ciliary body, 450, 500, 503
Classifications, 831, 833
Class-room, 757, 759, 806, 823
Cleanliness, 640, 723, 732
Cleansing, vacuum, 763
Climate, 768, 773, 779, 788
Clinics, 126, 183, 328, 638
Cloak-rooms, 748
Closets, 643, 752
Clothing, 88, 210, 223, 749
Cod-liver oil, 102, 145
Cold feet, 178, 211
Cold fingers, 210, 540, 792
Cold rooms, 211, 791, 792
Colds, 215, 239, 241, 787
Colour, 346, 483
Community, 145, 214, 743
Conduct, 315, 319, 364
Conjunctivitis, 454, 455
Consciousness, 296, 299
Consonants, 85, 602, 604
Contagion, 667, 770
Control Board, 382
Contol Committees, 432
Control in observation, 213, 831
Conveyance, 183, 468, 504
Convulsions, infantile, 399
Cornea, 448, 454, 485
Correlations, 4, 847, 852
Cortex of brain, 312, 363
Costs, recovery, 132, 212, 638, 639
Crampton index, 73, 787
Creeping, 154, 168
Cretinism, 394
Cripples, 180, 183, 185, 436
Curriculum reform, 187, 220
Cyanosis, 69, 280
Cycling, 89, 285

Daylight, 802, 804, 808, 813
Deaf, 44, 585–95, 599
Delinquency, 349, 365, 380, 420
Dementia præcox, 347, 409, 574
Dental care, 133–43, 232, 265
Dental clinic, 80, 140, 638
Dental hygienists, 136, 141, 443, 646
Desks, 160, 169, 186–200
Deviation, Standard, 839
Dextrality, 598, 624
Diet, 104–30, 132, 655
Dioptres, 468
Diphtheria, 141, 445, 686–701
Diving, 727
Drains, 753
Drawings, 444, 559, 560, 630
Dreyer's formulæ, 56
Drinks, 132, 643, 723
Dubois's formula, 97
Dunfermline, 18, 116, 120
Dust, 252, 762, 769, 775
Dysidrosis, 733, 740
Dysmenorrhœa, 90, 651

Ear discharge, 582, 642, 707, 835
Ear examination, 575
Echolalia, 323, 599, 617, 618
Education, 94, 314–322, 326
  Sex, 377, 378
Educational strain, 371, 376, 406, 439
Effort syndrome, 72, 81
Emmetropia, 471, 496
Emotional conditions, 81, 84, 315, 318
Encephalitis, 310, 411, 416, 716
Enteroptosis, 75, 78, 651
Enuresis, 153, 232
Environment and Education, 308, 332
Epilepsy, 89, 397, 401, 420
Error—
  Curve of, 836, 845
  Probable, 840, 846
Eton, 93, 361
Eustachian tubes, 227, 576
Evidence, children's, 322, 392
Eye, 447–543, 545, 563
  Accommodation, 465, 488, 523
  Adaptation, 464, 519, 522, 796
Exercise, 67–75, 289, 631
Exercises, 81–90, 230, 290

Faints, 398, 406
Family, 329, 426, 438, 667
Fans, electric, 782, 783
Fat, 101, 104, 129
Fatigue, 67, 126, 152, 221
Favus, 641, 735
Fear, 324, 441, 607
Feeding, school, 120–32, 207, 220
Fingers, 85, 196, 272, 309
Fixation area of vision, 467, 548
Flack's Air Force tests, 63, 283
Flat-footedness, 90, 174
Fleas, 702, 710
Floors, heating, 211, 440, 791
Food, 99–114, 129, 136
Foot, 90, 170–79, 191
Form board, 350, 351, 386
Frequency tables, 835
Furniture, 184, 186–201, 814

Games, 83, 258, 440, 742
Gas lighting, 785, 821
Genius, 310, 375
Gesture, 596, 611
Girl Guides, 94, 99
Glandular fever, 715
Glare, 512, 523, 526, 811
Grancher, L'Œuvre, 206, 246, 250
Greek statues, 56, 75
Grip, 34, 311, 350, 376
Growth, 13–52, 226, 277
Guides, 534
Gymnastic costume, 88
Gymnastic work, 74

Habit, 149, 161, 319, 328
Handkerchief, 59, 230, 242
Harrison's groove, 60, 232
Headache, 497, 504, 514, 811
Head attitudes, 64, 166
Health, 325, 635, 644, 647
Hearing, 575–84, 592, 602
Heart, 266–295
  Clinics, 286
  Dilated, 217, 224, 284
  Efficiency, 67, 72, 89
  Growth, 42, 55, 81, 280
Heat, 253, 766, 771, 773
Heating, 210, 783, 788–94
Heights, 15, 33, 51, 837, 838
Heredity, 2–12, 509, 537
Hernia, 89, 636
Hiccup, 369, 717
Holiday influence, 222, 709, 718
Hookworm, 9, 270, 404
Hospital, 180, 184, 737
Housing, 152, 587, 711
Humidity, 774, 779
Hutchinson's syndrome, 138, 462, 498, 590
Hydrocephalus, 393, 394
Hygienists, dental, 136, 141, 443, 646
Hypnotism, 272, 323, 480
Hysteria, 272, 369, 405

Idioglossia, 600
Idiot, 382
Illumination, 191, 531, 795–823
Imagery, 368, 418
Imbecile, 383–88
Imitation, 321, 390, 405, 439
Immunity, 662, 675, 693, 705
Impetigo, 734, 739
Industrial school, 153, 423
Infant schools, 642, 685
  Vision tests, 475, 505
Infants, 21, 85, 138, 318
  Nervous, 155, 254, 399, 716

Infection—
Class outbreaks, 699, 708, 713, 825
Dose of, 252, 265, 661, 703
Infectious diseases, 659–732
Nurses and notification, 643, 722
Out-of-school, 253, 702, 727
Regulations, 717, 721
Velocity of infection, 215, 663
Inferiority, sense, 74, 746, 759
Ink, 526, 549
Intelligence, 312, 331–52, 363
and conduct, 361, 364
and grip, 35, 311, 350, 376
and stature, 31, 361
and Vision, 849
Subnormal, 380–435
Tests, 333-53
Ionization, 583
Itch, 641, 659, 732

Jackson, Hughlings, nervous levels, 302, 310, 364
Journey, school, 69, 221, 223, 284
Junglegym, 91, 441
Juvenile Courts, 91, 423

Kallikak family, 11, 427
Kata-thermometer, 777
Katz light reserve, 804, 815
Kaup's index, 37, 119
Keratitis, Interstitial, 461, 537
Keratomalacia, 102, 107
Kyphosis, 159, 166

Labyrinth, 64, 86, 508
Lalling, 599, 600
Lavatories, 643, 751
Laziness, 328
Lead poisoning, 9, 404
Lees, cranial formula, 20, 350
Left-handedness, 444, 624, 629
Legal decisions, 142, 238, 402, 732, 739
Legibility, 552, 554, 557
Lenses, 449, 468, 491, 513
Letters, learning, 553, 561
Liars, 408, 417, 418
Lice, 642, 728–32
Light, 146, 797, 805, 820
Lip-reading, 581, 591
Lisping, 600
Logarithmic scale, 73, 627, 829
Lordosis, 159, 167, 233

McMillan, R., nursery school, 132, 827
Macula lutea, 449, 511, 534
Malnutrition, 108, 125, 239, 651
Measles, 445, 672–86, 825
Medical examinations, 181, 632–39, 646
treatment, 633–40, 643, 644
Memory, 37, 348, 374, 382
Meningitis, 225, 263, 585
Menstruation, 90, 378
Mental age, 334, 353
Mental defect, 232, 331, 381–435
Mentality—
of blind, 539
of deaf, 579
of unstable, 367
Metabolism, basal, 95, 129
Microcephaly, 394
Milk, 107, 111, 248, 262
Mind, 296, 302
Mongolism, 395
Moral imbecile, 366, 383, 413, 623
Morality, 93, 325, 412, 415
Moron, 381, 429, 432
Mother, 328, 368, 370, 443
Motor pathways, 306, 317
Mouth breathing, 60, 229, 241, 585
Mumps, 715
Municipal Societies, 643
Mydriatics, 468
Myope schools, 529
Myopia, 497, 509, 514, 518

Nail biting, 369, 651
Nasal obstruction, 134, 255, 601
Nasopharynx, 128, 273
Needlework, 590, 812
Nervous child, 254, 405, 407
Neurasthenia, infantile, 126, 254, 654
Neurons, 299, 308
New Zealand, 49, 111, 142, 145
Night terrors, 153, 232
Nurseries, day, 436
Nursery school—
Education, 326, 328, 594, 618
Health, 263, 594, 618, 684
Regulations, 438
Nurse's room, 644, 748
Nurses, 206, 263, 329, 642

Nutrition, 78, 95–132, 439
Nutrition classes, 38, 44, 126, 832

Oarsmen, University, 30, 31, 50, 119
Oblivion, pretraumatic, 297
Open-air classes, 37, 202–25, 264
Ophthalmia, 9, 425, 727, 835
  Sympathetic, 301, 305
Oral hygiene, 133, 141
Overcrowding, 665, 730
Oxycephaly, 393
Oxygen, 68, 70, 72
Ozone, 769, 786

Paralysis, 182, 184, 734, 830
Parents, 3, 387, 427
Pediculosis, 640, 728
Pedographs, 176, 177, 179
Pen, 531, 570
Personal equation, 259, 834
Personality, 320, 329, 365, 609
Phlyctenulæ, 234, 457
Photometer, 802, 805
Physique, 34, 53–94, 538
Pink eye, 457, 723
Play, 83, 92, 224, 371
Playground classes, 37, 203, 207, 218
Playgrounds, 75, 242, 316, 741
Plenum system, 784
Polioencephalitis, 271, 273
Poliomyelitis, 182, 436, 716, 831
Porteus maze, 349, 386
Postures—
  Diseased, 86, 158, 233, 539
  Normal, 54, 64, 65, 155
Pott's disease, 76, 160
Poverty—
  Defects, 121, 422, 426, 594
  Disease, 204, 207, 243, 261
  Growth, 28, 29, 49
  Social, 121, 361, 419, 651
Precocity, 31, 34, 151, 374
Presbyopia, 470, 496
Pre-school care, 21, 436–46, 581
Print, size of, 533, 550
Psycho-analysis, 272, 320, 324, 370
Psychopathic conditions, 363, 371, 372, 419
Puberty—
  Growth, 38, 43, 216, 378
  Heart, 41, 80, 86, 267
Public schools—
  Sport, 83, 84, 90, 413
  Health, 93, 276, 361, 675
Pulse rate, 68, 89, 266, 650
Punishments, 79, 372

Quarantine, 664, 710, 717
Quetelet's index, 116
  rules, 824

Reading, 160, 470, 544–58
Reflections, light, 798, 811, 813
Reflexes, nerve, 301, 319, 391, 618
Reformatory schools, 423
Regulations—
  Building, 741, 749, 757, 762
  Furnishings, 200, 748, 752
  Heating, 793
  Lighting, 812
  Special services, 141, 438, 633, 722
  Ventilation, 782, 792
Respiration, 61, 63, 771
Rest, 127, 186, 202, 210
Retina, 448, 463, 480, 485
Retinal detachment, 498, 509, 534
Retinitis pigmentosa, 461, 485, 537, 587
Retinoscopy, 491, 494, 505
Rheumatism, 266–95, 651, 829
Rickets, 29, 47, 143
Ringworm, 641, 659, 736, 737
Röntgen rays, 146, 148, 256, 738
Rosenbach's test, 480, 627
Running, 68, 72, 85, 172
Rupture, 89, 636

Scabies, 641, 659, 732
Scarlatina, 237, 696, 701–11
Schick test, 687, 690
Scholarships, 28, 89, 132, 636
School Clinics, 239, 328, 637, 644
School closure, 679, 683, 721
Schools (or classes)—
  Cardiac, 218, 274, 292, 294
  Convalescent, 261
  Cripples, 180, 183, 292, 294
  Democratic, 222, 242, 742
  Derbyshire, 747, 774, 791, 812
  Epileptic, 401
  Favus, 736
  Industrial, 423
  Intermediate, 358, 381, 385, 391
  Invalid, 218, 294
  Myope, 529
  Nursery, 438
  Observational, 592, 623

Schools (or classes)—
Open-air, 205, 221, 746
Orienting, 223, 274
Primary, 242, 264
Sight-saving, 529, 534
Special—
Blind, 540, 542
Deaf, 590
Hard of hearing, 593
Mentally defective, 390
Staffordshire, 747, 774
Tuberculosis, 261, 264
Scoliosis, 164, 178
Script writing, 477, 531, 555, 569
Seasonal variation in growth, 35–9, 128, 213
Seats, 186–92
Secondary schools, 44, 48, 132, 833
Segregation, 10, 430
Sex, 6, 8, 377, 831
Shoulder blades, 79, 158, 162, 193
Sigmatism, 134, 600, 650
Sites, 741, 743, 744
Skin, 79, 97, 690, 704
Skipping, 90, 173, 177
Sky, visible, 800, 809
Sleep, 149–53, 210, 440
Smallpox, 536, 662, 712, 713, 850
Sneezing classes, 60, 230
Soap, 723, 738, 740
Space, school, 169, 561, 742, 754
Spectacles, 457, 513, 514
Speech, 391, 443, 590, 596
Spine, 154–69
Sportsmanship, 84, 90
Squint, 442, 470, 486, 596
Stammer, 443, 599, 605–9
Stanford, scale, 333, 349
Starvation, 132, 332, 425
Statistics, 824–52
Status lymphaticus, 236, 253
Stem length, 15, 57, 129
Stereoscope, 487, 521
Sterilization, 10, 423, 430, 587
Stiller's sign, 78
Suggestion—
in education, 90, 321, 392, 795
as treatment, 272, 406, 480, 574
Suicide, 375, 408, 409
Sunlight, 144, 264, 474
Sunshine, 269, 523, 742, 812
Swimming, 93, 173, 279, 442
Symbols, 94, 596, 611
Syphilis, 9, 384, 399, 536, 590
Hutchinson's triad, 138, 462, 498
Tachycardia, 72, 291
Tallquist's method, 268
Teachers—
Amenities, 370, 648, 656, 769
Candidates, 81, 132, 517, 651
Disorders, 178, 400, 653, 655
Hygiene knowledge, 210, 219, 541, 643
Risks, 366, 656, 715, 792
Work, 225, 390, 581, 647
Teeth, 133–42, 232, 236
Temperament, 74, 305, 348
Temperature, 257, 270, 291
Thieves, 418
Throat, sore, 234, 669, 710, 775
Thyroid, 79, 235, 281, 395
Tinea cruris, 740
Tinea tonsurans, 736
Tobacco, 484, 556, 574
Toddler, 150, 154, 413, 436
Tone, muscular, 54, 64, 72, 305
Tonsils, 226–37, 289, 694
Towels, 456, 643, 723, 749
Town dwellers, 74, 209, 328, 692
Trachoma, 458, 727
Traffic, wheeled, 92, 437
Training, 85, 90, 661
Tremor, 80, 89, 406, 574
Truants, 419, 642
Tuberculosis, 243–65
Cost, 212, 260, 262, 265
Cripples, 160, 178, 182, 184
Latent, 245, 251, 254, 257
Milk, 248, 251, 262
Mortality, 257, 259, 652
Regulations, 258, 259
School, 204, 247, 264
Surgical, 79, 248
Teachers, 652
Turbinate bones, 227, 239
Types, physical, 75, 88, 253
Typhoid fever, 225, 425, 665, 751
Vaccination, 633, 712, 715, 850
Variation, coefficient, 844, 845
Varicocele, 636
Vapour tensions, 777
Vegetables, 109, 128, 209
Ventilation, 764–88
London enquiry, 767, 786
New York Commission, 768, 779, 787
Venus of Milo, 75

Verbalists, 78, 348, 417, 540
Vermin, 152, 642, 730, 731
Vincent's angina, 688
Vision, 447–527
  Acuity, 471, 482, 849, 850
  Binocular, 479, 480
  Span of, 467, 547
  Stereoscopic, 311, 316
  Sub-normal, 528–34
Vital capacity, 33, 55–64
Vitamin, 107, 110
Voice hygiene, 600, 654
Voluntary workers, 184, 645, 646
Vowels, 580, 591, 601

Walking, 85, 174
Warming, 766, 789–94
Washing, 131, 723, 749
Water, 138, 749, 750, 751
Weights, 19–50
  Illness, 141, 236, 240, 677
  Nursery, 439, 446, 827
  Nutrition, 116–20, 126, 128
Weights—
  Seasonal, 208, 214
  Variations, 40, 47, 439, 843
Welfare centres, 442
Whooping-cough, 446, 670
Windows, 211, 781, 793, 805
Women, 63, 80, 132, 377
Word-blindness, 614
  Deafness, 579, 615
  Forms, 557
  Memories, 307
Work, out of school, 83, 285, 636, 637
Writer's cramp, 570, 574
Writing, 309, 559–74, 630
  Bad, 569, 571, 573
  Mirror, 561, 628

Xerosis, 461, 690

Yerkes point scale, 347, 353, 355

Zymotics, 668, 721

GEORGE ALLEN & UNWIN LTD.
LONDON: 40 MUSEUM STREET, W.C. 1
CAPE TOWN: 73 ST. GEORGE'S STREET
SYDNEY, N.S.W.: WYNYARD SQUARE
WELLINGTON, N.Z.: 4 WILLIS STREET

Psychological Healing

By PIERRE JANET

Translated from the French by EDEN and CEDAR PAUL

Medium 8*vo.* *In Two Vols.* £2 2*s.*

"The book is an almost exhaustive account of what has hitherto been accomplished, and a testimony to the crying need for future research."—*The Times Literary Supplement.*

Principles of Psychotherapy

By PIERRE JANET

Translated by H. M. and E. R. GUTHRIE

Demy 8*vo.* 10*s.* 6*d.*

"As a descriptive psychopathologist Janet is unrivalled. . . . The book is full of shrewd observation."—*Lancet.*

The Personal Equation

By LOUIS BERMAN, M.D.

La. Cr. 8*vo.* 8*s.* 6*d.*

Man is primarily determined in his behaviour by his glands. Readers of this book will be stimulated to study and classify every individual with whom they come in contact as Thyroid, Pituitary or Adrenal types, according to their dominating gland secretion.

"The work deserves to be widely read and studied by all . . the product of a well-stored mind."—*Pharmaceutical Journal.*

The Internal Secretions

For the Use of Students and Physicians

By Dr. ARTHUR WEIL

Authorised Translation by JACOB GUTMAN, M.D.

Medium 8*vo.* 18*s.*

"The subject is of great interest. It has side-bearings upon sociology, criminology, and even psychology, and the research into the internal secretions has resulted in the most spectacular triumphs of modern medicine."—*Spectator.*

Vitamins

A Critical Survey of the Theory of Accessory Food Factors

By RAGNAR BERG

Translated by EDEN and CEDAR PAUL

Demy 8*vo.* 18*s.*

"It is one of those marvels of ant-like industry which we associate with German science. . . . An amazing book."—*Nation.*

Elements of Vital Statistics

By Sir ARTHUR NEWSHOLME, K.C.B., M.D.

Demy 8*vo.* *New Edition. Entirely rewritten.* 24*s.*

"Sir Arthur Newsholme laid this country under a great debt of gratitude while he was still at the head of the Public Health Service; the present volume achieves another signal service."—*The Times.*

Public Relief of Sickness

By GERALD MORGAN

Cr. 8*vo.* 7*s.* 6*d.*

"The book is well worth reading, and we commend it to the attention of all those who have to do with the working of the National Health Insurance Act in whatever capacity."—*Medical Times.*

Text-Book of Psychiatry

By Professor Dr. EUGEN BLEULER

Translated by A. A. BRILL, Ph.B., M.D.

Royal 8*vo.* 25*s.*

"We can cordially recommend this solid and important contribution to psychiatry to all those who take a serious interest in the problems of mental disorder."—*British Medical Journal.*

The Kingdom of Evils : Psychiatric Social Work

By E. E. SOUTHARD, M.D., and M. C. JARRETT

Demy 8*vo.* 24*s.*

"Those engaged in Mental Welfare work will find this book of great practical value."—*Medical Times.*

Australian Totemism

A Psychoanalytic Study in Anthropology

By Dr. GÉZA RÓHEIM

With an Introduction by M. D. EDER

Royal 8*vo.* *With Maps* 35*s.*

"His detailed and acute analysis offers a solution of many problems, and his conclusions as to the composition and origin of the Australian race are most suggestive and will need mature consideration. . . . A notable and weighty contribution to anthropological discussion."—*Manchester Guardian.*

LONDON: GEORGE ALLEN & UNWIN, LTD.
RUSKIN HOUSE, 40 MUSEUM STREET, W.C.1

LANE MEDICAL LIBRARY

To avoid fine, this book should be returned on
or before the date last stamped below.

SAN FRANCISCO TUBERCULOSIS ASSN.